Ann. For. Res. 67(1): 55-76, 2024
https://doi.org/afr.2024.2670

ANNALS OF FOREST RESEARCH
www.afrjournal.org

Landscape fragmentation and connectivity as key variables on occurrence of human-wildlife interactions

Ileana Pătru-Stupariu[1], Mihai Mustățea[2]✉, Mihai-Răzvan Niță[3], Mioara Clius[4]

Pătru-Stupariu I., Mustățea M., Niță M. R., Clius M., 2024. Landscape fragmentation and connectivity as key variables on occurrence of human-wildlife interactions. Ann. For. Res. 67(1): 55-76.

Abstract Human-wildlife interactions (HWI) are one of the most highly studied topics from the fields of wildlife management and are reported to be increasing globally as anthropogenic lands uses expand into wild lands, especially in mountainous areas where forest habitats are in the proximity of human settlements. The upper Prahova Valley in south-central Romania provides habitat to several native charismatic wildlife species. Since 1990 this area has become a major tourist destination now characterized by a high density of major transport infrastructures and homes. To assess how the changes in land use have affected HWIs, from September 2018 to August 2019, we discussed with 370 local citizens from the cities of Sinaia, Bușteni and Predeal. We developed maps of wildlife habitat fragmentation and connectivity and superimposed them over the locations with the HWI hotspots. According to the results, over 50% of the hotspots identified where located in areas exhibiting the greatest level of fragmentation, and the species frequently involved in interactions were the brown bear (*Ursus arctos*), wild boar (*Sus scrofa*), and red fox (*Vulpes vulpes*). The maps suggest that habitat fragmentation could represent a primal cause for the regions' high frequency of animal descents into settlements, since wildlife habitats and ecological corridors are affected by the fragmentation of anthropogenic infrastructures especially in the proximity of major settlements. As a conclusion, our results highlight the need for sustainable landscape planning in order to optimize biodiversity management and diminish interactions between humans and wild animals, based on: a) mapping the areas characterized by high quality wildlife habitats and including them into a system of strict protection, b) developing or enhancing wildlife ecological corridors to favour animal movement between intact ecosystems, and c) regulating the expansion of human infrastructures in the proximity of strictly protected habitats.

Keywords: anthropogenic infrastructures, connectivity, fragmentation, hotspots, human-wildlife interactions, Romania, tourism.

Addresses: [1]Department of Regional Geography and Environment, Faculty of Geography, University of Bucharest, Bucharest, Romania, Bucharest, Romania. | [2]Doctoral School Simion Mehedinti, Faculty of Geography, University of Bucharest, Romania. | [3]Centre for Environmental Research and Impact Studies, Faculty of Geography, University of Bucharest, Bucharest, Romania. | [4]Faculty of Geography, University of Bucharest, Bucharest, Romania.

✉ **Corresponding Author:** Mustățea Mihai (mihai.mustatea@drd.unibuc.ro).

Manuscript: received November 6, 2022; revised May 31, 2024; accepted June 6, 2024.

Introduction

The nature of Human-Wildlife interactions (HWIs) is a contemporary issue that affects biodiversity conservation and decision - makers in public administration and wildlife management (Messmer 2000, Hull et al. 2023). Negative HWIs that result in increased human - health and safety concerns or economic loses can affect wildlife species conservation (Schultz et al. 2017, Conover 2019, Griffin & Ciuti 2023). Interactions between humans and wild animals may generate conflicts when an action of one of the parts implicated causes a negative impact on the other (Messmer 2000, Can - Hernandez et al. 2019). Human-Wildlife conflicts are increasing globally, especially in rich - biodiversity areas where the continuous expansion of human settlements, tourism infrastructures, and agricultural areas have resulted in wildlife habitat loss and fragmentation (Treves & Karantah 2003, Messmer 2009, Basak et al. 2022). As the anthropogenic infrastructure encroaches into wildlife habitat, the species which were once involved in sporadic interactions have now become a common source of conflict and human insecurity in settlements, and the interest for their investigation rises (Messmer 2009, Neagu et al. 2022, Pop et al. 2023).

Conversely, positive HWIs are characterized by situations when humans and wildlife peacefully coexist or even thrive because of the interactions (Konig et al. 2020). Such situations are usually based on the intrinsic and recreation value of wild animals (Manfredo et al. 2020). Coexistence can be potentially useful to humans and animals and can promote wildlife sustainable management and durable tourism activities. Common examples include wildlife watching, swimming with marine mammals or fish, sportive fishing, diving with marine wildlife, and safari (Frank 2015).

The impact of wildlife habitat fragmentation on HWIs has been widely analysed. Studies suggest that fragmentation of wildlife habitats due to increasing human population generates higher rates of livestock depredation by jaguars (*Panthera onca*) in Brazil and cougars (*Puma concolor*) in Canada (Michalski et al. 2006, Thornton & Quinn 2009). Increased habitat fragmentation may also contribute to lower densities of wild prey species which has been implicated in higher levels of livestock depredation by leopards (*Panthera pardus*) in India (Kala & Kothari 2013).

Increasing wildlife dispersion along wildlife corridors connecting natural parks, followed by the extensive use of the same corridors by humans for resource extraction are the main causes generating high rates of conflicts in northern India (Malviya & Ramesh 2015). Agricultural expansion that fragmented large native feline habitats resulted in increased Human-Wildlife conflict in Tanzania (Mponzi et al. 2014) and Costa Rica (Amit et al. 2013) and conflicts between elks (*Cervus canadensis*) and farmers in Canada (Brook et al. 2009). Other assessments determined that the changes in forest composition and configuration induced by the fragmentation of agricultural areas (i.e., proportion crop perimeter adjacent to the forest, amount of forest and forest edge, mean size of forest patches etc.) have a major influence on the characteristics of crop damages caused by wildlife (DeVault et al. 2007, Beasley & Rodes 2008, Retamosa et al. 2008). Several studies analysed conflicts between locals and wildlife because of increasing habitat fragmentation and built - up development in the proximity of protected areas (Baldwin & Bender 2009, Borah et al. 2018, Singh et al. 2018, Biset et al. 2019).

Roads as a manifestation of human development have may further fragment landscapes and contribute to increased wildlife - vehicle collisions (Chen & Wu 2014, Joshi & Puri 2019, McDonald et al. 2019). Sparks and Gates (2012) reported that culverts beneath roadways may enhance wildlife habitat connectivity and reduce wildlife vehicle collisions. Osipova (2018) suggested that fencing could also reduce collisions without changes in habitat connectivity.

Within the Carpathian Mountains of Romania, a region where wildlife habitats are highly fragmented, Straka et al. (2012) and Kubala et al. (2020) analized the genetic differentiation between subpopulations of large carnivorous mammals, because of spatial isolation due to increasing human infrastructures. Fedorca et al. (2019) used genetic information to assess how landscapes spatial features influence the demographic connectivity of large mammals' population and to identify the areas where potential future development of major roads could intersect ecological corridors. Furthermore, through multispecies spatial models, Fedorca et al. (2020) identified areas crucial for connectivity conservation for brown bear (*Ursus arctos*), grey wolf (*Canis lupus*), red deer (*C. elaphus*), and wild boar (*Sus scrofa*), to analyse and mitigate the effect of transport infrastructure over wildlife habitats.

A wide range of species are involved in HWI (i.e., rare or common, specialist or generalist, protected or with less conservation value), especially in densely populated mountain ranges, such as the case of the Carpathian Mountains of Romania. These are areas of ancient human habitation and are recognized for the coexistence between local people and large predatory mammals, especially brown bears (Rozylowicz et al. 2010, Popescu et al. 2019, Kubala et al. 2020). Centuries of conflicts led to the extinction of brown bears in the largest part of Western Europe, and favourable conservation status in modern times was crucial for their survival. By consequence, efforts were allocated to analyse and manage the factors that trigger conflicts with humans in the rural areas of Romania (Rozylowicz et al. 2011, Ionescu 2016, Cristescu et al. 2019). Canines, especially grey wolf, golden jackal (*C. aureus*), and red fox (*Vulpes vulpes*), are frequently involved in Human-Wildlife conflicts because of their extended home ranges, complex diet and adaptable feeding habits, and are responsible for attacks on domestic livestock (Nyhus 2016, Sin et al. 2019, Khorozyan and Heurich 2022). Mustelids, namely European polecat (*Mustela putorius*), least weasel (*Mustela nivalis*), and stone marten (*Martes foina*), are the main cause of damage among domestic birds (Zabala and Zuberogoitia 2005). Omnivorous mammals, particularly wild boar and roe deer (*Capreolus capreolus*) are known for their destructive impact on open spaces, arable land and even forested areas (Kamler et al. 2015).

To better manage conflicts that may results from HWI, an increased emphasis must be placed on studying the human dimension of the phenomenon (Messmer 2009, Marchini & Crawshaw 2015). Traditional social disciplines (such as sociology or psychology) include subfields focused on environmental conservation and interdisciplinary areas in which the foundation is represented by the human perspective of the environment (Bennett et al. 2016). Successful wildlife conservation involves the acknowledgement that humans play a major role in the problem (Messmer 2000, Vayro et al. 2023). To encourage human and wildlife coexistence by mitigating conflicts, it is vital to analyse and forecast the human attitude towards wildlife at various levels, such as individual, social and administrative. Furthermore, it is imperative to enhance the cooperation between local citizens and governments to increase human tolerance of conflicts (Messmer 2009 , Tampakis et al. 2023, Roth et al. 2024). Achieving consensus between government authorities, local communities. and environmental conservationists are all essential to decrease conflicts with wild animals, understand the needs and cultural values of locals and promote education and sustainable economic development of areas affected by HWI (Messmer 2000, Schultz et al. 2017). Analysis over local citizens perspective on the characteristics of conflicts represents a wide - spread approach and plays a crucial role in improving long - term conservation of biodiversity and reducing risks to human security and economic activities (Borah et al. 2018, Biset et al. 2019).

Our study focused on assessing the influence of habitat fragmentation over the spatial distribution of HWI hotspots in Romania. Local citizens' perceptions could help managers better understand HWIs in rich - biodiversity areas by identify the areas where the landscape ecological functionality is hindered by poor spatial planning and precarious legislative regulations which may be major driving forces of conflicts (Neelakantan et al. 2019). We sought highlight the spatial gaps which favour ecological dysfunctionality to prioritize the implications of mitigating conflicts and enhancing future spatial planning actions. The spatial quantification of wildlife habitat and ecological corridors fragmentation use of landscape metrics could identify better the ecological disturbances generated by intensive human activities over natural ecosystems and the implications that these disturbances have on interactions with wild animals (Morzillo et al. 2014, Popescu et al. 2022).

The purpose of our study to assess how habitat fragmentation affects the occurrence of HWI. Specifically, we wanted to; 1) to quantify the habitat fragmentation of wildlife involved in conflicts with local citizens, and 2) to analyse the connectivity of wildlife ecological corridors and the spatial distribution of HWI hotspots. Based on the complexity of HWI and the importance of understanding the implications of habitat fragmentation over the phenomenon, we hypothesized that HWIs are concentrated in the proximity of settlement outskirts, where wildlife habitats are fragmented, and ecological corridors are poorly connected." Our research question being, is there a connection between landscape fragmentation, poor connectivity and HWI locations? To achieve our goals, we characterized the landscape features that contributed to increased HWIs, gather information about conflicts, and to map the hotspots. We mapped interaction hotspots based on the results of questionnaire surveys. We then modelled the habitat suitability for the wild boar, the red fox, and the brown bear and assessed the connectivity between suitable habitat patches for each species. Finally, we have overlaid connectivity and interaction maps to identify and characterize areas of conflict.

Materials and Methods

Study area

Our study was completed in the upper Prahova Valley, which lies at the contact between the southern and eastern Carpathian Mountains, in south - central Romania (Figure 1). The landscape covers 26067 ha, and it is divided between forests (19547 ha / 75% of the total landscape area), alpine grasslands and meadows (4767 ha), artificial areas (1487 ha), heath and shrubs (287 ha), and bare rock (165 ha). Within the forest area, 13109 ha are mixed, 5493 ha are coniferous, and only 945 ha are broadly leafed (European Environmental Agency 2018). The area preserves isolated patches of high conservation value forests (Pătru - Stupariu et al. 2013). The valley is in the alpine biogeographical region. The main broad - leafed species are European beech (*Fagus sylvatica*), while common coniferous include European spruce (*Picea abies*), European silver fir (*Albies alba*), and European larch (*Larix decidua*).

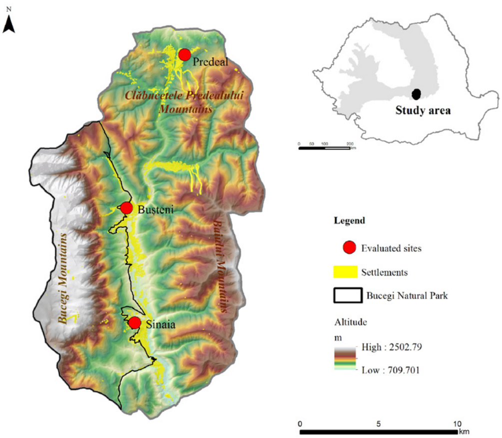

Figure 1 The location of the study area – the upper Prahova valley from Romania, and the three sites investigated for human-wildlife interactions between September 2018 and august 2019 - Sinaia, Bușteni and Predeal.

Wildlife species in the study area include both charismatic and protected mammals, such as large carnivores, especially brown bear, grey wolf and European lynx (*Lynx*

lynx). Common herbivores were the Alpine chamois (*Rupicapra rupicapra*), red deer, and roe deer. Several protected areas are designated for the valuable natural patrimony, representative being a natural park (established in 2003), Natura 2000 site (established in 2007) and several reserves, all of them being administrated by National Forestry Agency - Romsilva (Romsilva 2020).

The major economic centres of the study area are Sinaia, Bușteni, Predeal and Azuga. These cities are some of the most important centres of Romania for winter tourism and offer the infrastructure for practising both traditional activities (especially skiing) and modern ones (such as snowboarding or skiboarding) and organizing winter sports events (Huntuș 2016). After 1990, the tourism industry was restructured by capitalist economic practices through the rise of private entrepreneurs and the interest of international and organizations in the development of the area. The number of guesthouses has increased considerably, new cable transportation infrastructure was constructed in the resorts, and modern types of winter sports services and infrastructures were developed (Voiculescu et al. 2012). The area is characterized by a high density of major transport infrastructures, and numerous local roads and touristic trails. Therefore, the landscape has been drastically fragmented. Also, the practice of unorganized tourism caused significant damage and the forested areas were overexploited especially at the end of the week, tourists visibly contributing to the degradation of the landscape by abandoning household waste in campsites and overusing of the touristic trails (Vărvăruc et al. 2016).

The interactions with wildlife have become a common aspect of the inhabitants who live in urban areas of the Prahova Valley and have increased in the post - socialist period (Pătru - Stupariu et al. 2020). These interactions have become increasing negative because wildlife species have lost their fear of people and the loss of security and material losses by experienced by humans (Mustățea & Pătru - Stupariu 2021). The most common damages caused by wildlife to humans include the deterioration of fences and garbage dumpsters by brown bears, and the rooting of open spaces by wild boar (Cimpoca and Voiculescu 2022, Cimpoca et al. 2024). These conflicts usually end with a replacement or even elimination of the problematic animal (Pătru - Stupariu et al. 2020). Therefore, the upper Prahova Valley is one of the areas with the most intense HWI in all Romania. The valley is very suitable for our assessment concerning the effects of habitat fragmentation on HWI, due to the presence of protected areas that are inhabited by stable populations of numerous wildlife species, especially large predatory mammals (Figure 2a), a high magnitude of HWI leading to human economic loss, insecurity, and the necessity to apply measures of prevention (Figure 2b), and high density settlements in the central areas and increasingly expanding leisure facilities into forested areas at the peripheries (Figure 2c), and wildlife habitat fragmentation by roads, tracking trails and touristic infrastructures (Figure 2d).

Figure 2 Field evidence supporting the relevance of the settlements from the upper Prahova valley of Romania as areas proper for studying the effect of habitat fragmentation on the human-wildlife interactions phenomenon (a - footprints of a brown bear at the outskirts of Bușteni, June 2019; b - warning sign evidencing the potential of encountering bears on the touristic trails in the proximity of Sinaia, September 2018; c - wildlife habitat fragmentation due to expansion of accommodation units into initial forest areas at the outskirts of Bușteni, June 2019; d - wildlife habitat barrier generated by the highly crowded national road in the city centre of Bușteni, June 2019).

Identifying HWI hotspots

Our assessment involved contacting, from September 2018 to August 2019, residents in our study area to determine the wildlife species which were frequently involved in HWIs (Dorresteijn et al. 2015). HWI can be positive, negative, or benign. Wildlife daily interaction it is when the interaction becomes negative, that there is increased cause for concern. These negative interactions are often referred to as conflicts (Messmer 2000). For our study, since our data was not grouped into negative and positive interactions, we will use the term Human-Wildlife interactions, with the specification that these interactions have the potential to materialize into conflicts. We used several criteria to determine the settlements which were most representative in the context of HWI. Our criteria included; 1) the presence of expanding tourism accommodation units, hiking trails and transport infrastructures (such as the European road E60, dense networks of smaller roads, and the electrified double - track București - Brașov), that are potentially responsible for wildlife habitat fragmentation, 2) a high magnitude of HWI as reported by local citizens in previous discussions, and supported by media sources, and 3) initial field evidence of measures applied by local people mitigate HWI (i.e., use large breeds of watchdogs, reinforcement of fences or the avoidance of activity after nightfall). The settlements selected for the study included Sinaia, Bușteni and Predeal. We have excluded Azuga from our analyses because it is a small city located in an isolated area, where habitat fragmentation is not expected to be as intense as in the case of the other large urban areas, which are developed alongside the railway and European road. The number of inhabitants in the Valley was estimated at 32,053 (Simon & Bogan 2014). The population was distributed as follows at the urban area's level: Sinaia 11,822 inhabitants, Bușteni 10,013 inhabitants, and Predeal 5,282 inhabitants. For all the three urban areas, the population density did not exceed 200 inhabitants / km^2 (Simon & Bogan 2014).

We have stratified our sampling effort and applied a sampling approach which started from the outskirts of the settlements located in the proximity of forests (where HWI were expected to be most numerous), towards the central areas (characterized by a higher density of building and roads). We have selected for the analyses every single housing unit within the settlements, represented by households, apartment blocks and accommodation units. We personally went to each housing unit and tried to contact the tenants orally, through face - to - face interviews. The questionnaire was administered by hand out. We have discussed with only one person per housing unit, to avoid oversampling (as in the case of large apartment blocks or accommodation units). If more tenants showed up at a single housing unit, we chose for the interview the one who knew the area for a longer period and who interacted more often with wild animals. In case that the housing units' tenants declared themselves interested to participate in the study, we have applied the questionnaire. If the owners indicate that they are not interested in the subject, or if by various reasons, they were not available, the respective housing units was assessed as „no data". In case that the owners were available, but they suggested that HWI did not take place in the proximity or within their household, the housing unit was assessed as „no HWI". Overall, we were able to talk to 449 housing unit owners, of whom 370 said they had interacted with wild animals in the vicinity of their home and therefore decided to participate in the questionnaire (142 in Sinaia, 178 in Bușteni and 50 in Predeal) (Table 1).

Because we were interested in extracting information regarding the tenants' experience with wild animals that happened in the proximity of their households, the questionnaire contained specific questions aimed at identifying the species involved in HWIs, respectively the frequency of those interactions. Therefore, we have applied two questions: a) "Have you ever interacted with wildlife in the proximity of your household? If yes, mention which species", and b) "How

Table 1 The number of respondents in terms of gender, appurtenance to the type of housing unit, and social-economic status, within the settlements of Bușteni, Sinaia and Predeal, from the upper Prahova Valley of Romania, as reported by local citizens between September 2018 and August 2019

Settlement		Sinaia	Bușteni	Predeal	Overall
Gender	Male	72	91	21	184
	Female	70	87	29	186
Housing unit	Households / apartment blocks	87	165	9	261
	Accommodation units	55	13	41	109
Social - economic status	Employee	82	118	33	233
	Retired	60	60	17	137

often do these interactions took place?" (average number of days/year when the respective species was present) (Pătru - Stupariu et al. 2020).

To protect the respondent's identity, their anonymity was ensured in accordance with the provisions of the GDPR. The survey protocols were reviewed and received institutional approach. Discussions with the locals started only after they gave the verbal note. The extracted information was processed exactly as originally specified.

Mapping HWI hotspots

For all the housing units where we received a completed respondent questionnaire, we plotted the geographic coordinates. To identify the major HWI hotspots based on the public survey, we then analysed the frequency of interactions with wild animals in settlements as reported by our respondents, and grouped the data into several major categories: 1) rare and sporadic interactions, which happen in only several days per year, 2) seasonal interactions, specific to one, or maximum two seasons, and 3) frequent interactions, which took places in almost all the seasons, except a month or two from winter. We eliminated housing units characterized by sporadic HWI from our analysis, since these households are implicated only in occasional interactions and do not reveal a clear pattern of the problem. We selected for the further analysis only the housing units involved in seasonal and frequent interactions and analized their spatial distribution. The areas where we could identify spatial clusters of housing units seasonally or frequently affected by HWI were marked as HWI hotspots.

HWI metrics

We subsequently searched the published scientific literature to determine the effects of habitat fragmentation on the ecological behavior for the species most implicated by our respondents in HWI. These species included the brown bear (Pop et al. 2012, Sandu 2012, Roelling et al. 2014, Popescu et al. 2017, Cristescu et al. 2019), wild boar (Thurfjell et al. 2009, Bosch et al. 2014, Janoska et al. 2018, Tack 2018, Kim et al. 2019), and red fox (Weber & Meia 1996, Cagnacci et al. 2004, Prigioni et al. 2008, Holmala & Kauhala 2009, Tsunoda et al. 2017, Giuliano et al. 2019, Table 2).

We then extracted three datasets consisting of spatial elements which influence the ecological behavior of these species. The first dataset was a digital elevation model (DEM), extracted from the European Digital Elevation Model (EU - DEM), version 1.1, resolution of 25 m (European Environmental Agency 2017). The second encompasses land cover, roads, rivers and settlements, and was extracted from the latest Open Street Map database (Open Street Map 2019). The roads were converted into polygons with different buffer widths (expressed in meters), as it follows: major national roads - 2 x 10 m, secondary regional roads - 2 x 5 m, local roads - 2 x 2.5 m, railroads - 2 x 10 m, and cable car infrastructures - 2 x 10 m (Pătru - Stupariu et al. 2015).

We accounted for permanent and occasional settlements and reclassified them into five categories: 1) economic units (commercial, religious and touristic facilities), 2) residential units, 3) transport units (parking areas and stations), 4) seasonal sheepfolds, and 5) seasonal campsites.

Table 2 The ecological requirements regarding habitat fragmentation, shelter, resources and human security, which characterize the species implicated in human-wildlife interactions, brown bear, wild boar and red fox, within the settlements of Bușteni, Sinaia and Predeal, from the upper Prahova Valley of Romania, as reported by local citizens between September 2018 and August 2019

Habitat fragmentation	Shelter requirements	Food and water resources	Human security
Brown Bear			
- Forests patches with large core areas, located far away from settlements and roads. - Forests bordered by rivers or rocky areas used for dens. - Large patches of compact forests, well connected, which favours the species movement.	- Altitude: mainly between 600 and 1200 m. - Slope exposition: frequently sunny ones (S, E, SV, SE), rarely the cool ones (NE, V, NV and N); - Slope degree: usually areas with steep slopes, hard to reach.	- Land cover: mainly areas with mixed forests, followed by deciduous, conifers, transition forests and rarely pastures. - Forests consisting in old trees, with hollows and diameters over 120 cm, as well as compact, hard-to-reach softwood thickets and rich vegetable carpet regions. - Distance to water: below 250 m (as the distance increases, the favourability decreases).	- Areas hard accessible for humans due to stiff slopes or located far away from settlements and major roads. - Den distance from human infrastructures: mainly above 1000 m in case of permanent settlements or frequent used roads and over 250 m for forest roads.
Wild boar			
-Can thrive in fragmented forests.	-High elevation (over 1000 m); -Gentle slope ridge. -Higher frequency on the north aspect slopes, but with not significantly differences. -Prefers ridges over valleys or slopes. -Shelters disposed in the proximity of streams, in swampy forests, tall grass or heavy shrub thickets.	- Deciduous and mixed forests usually composed of oak and beech. -Transitional woodland-scrubs, grasslands, bare rocks, sparsely vegetated areas. -Pastures, complex cultivation patterns, land principally occupied by agriculture, with significant areas of natural vegetation. -Neutral preference for agricultural areas. - Forests enclosing marshes or meadows.	-Usually avoids artificial areas, but some individual's present signs of preference for urban areas.
Red fox			
-Can thrive in fragmented forests.	-Lower altitudes (1000–1500 m) (cold season); -No clear pattern (warm season).	-Forests bordered by open spaces. -Wooded areas (winter). -Grasslands (summer and autumn).	-Rare activity near human settlements.

The rivers were converted into polygons with specific buffer widths: large rivers (order 2 - 2 x 10 m), medium (order 3 to 4 - 2 x 5 m) and small and temporary ones (order 7 - 2 x 2.5 m). We classified the land cover was reclassified into five categories: 1) built - up (cemetery, military, industrial, parks, quarry and residential areas), 2) open spaces (farms, meadows and grasslands), 3) bush vegetation (shrubs and heaths), 4) bare rocks, and 5) forests. The settlements, roads, rivers and land cover reclassified datasets were merged concerning the following rule: settlements and roads fragment rivers, and all together fragment land cover (Botequila et al. 2006). For the third dataset, we have extracted the areas with potential virgin forests from the Primary Forests Potential Map of Romania (Greenpeace 2017).

We then quantified the fragmentation of habitats for brown bear, wild boar and red fox, using landscape metrics. The dataset we used to do this was developed at the previous step which encompasses land cover features significant for the species ecology.

We computed landscape metrics only for the forest land cover class since all the three species are forest generalists which depend primarily on forest habitats (Cristescu et al. 2019, Giuliano et al. 2019, Kim et al. 2019), and the forest land cover class represents the landscape matrices (by covering over 50% of the total landscape area) (Botequila et al. 2006, Pătru - Stupariu et al. 2011). Because our study was developed at a small local scale, the metrics were applied at the lowest landscape - level - patch. The metrics were computed by using FRGSTATS software (McGarigal & Marks 1995). We chose FRAGSTATS because the software has already implemented the algorithms for a complex palette of fragmentation metrics, including the ones selected for our assessment, it is a freely available as an open - source product, and it can compute landscape metrics at all of the three different levels of hierarchy (patch - level, class - level and landscape - level) (Botequila & Ahern 2002, Neel et al. 2004, Cushman et al. 2008, Csorba & Szabo 2012).

The selected metrics we chose can quantify the effect of fragmentation over wildlife habitats from a wide range of perspectives: ECON (Edge Contrast Index) - edge effect; CORE (Core Area) - the amount of core area, SHAPE (Shape) - compactness or geometric complexity of patches, PROX (Proximity) - patch isolation or connectivity between patches (inter - connectivity); and GYRATE (Radius of Gyration) - patch extensiveness, connectivity within patches (intra - connectivity) (Botequila et al. 2006, Gilleland 2010, Morzillo et al. 2014, Huguenin 2015). We modeled the CORE metric only for the brown bear because in case of the wild boar and red fox we were hampered by the poor availability of scientific data regarding habitat core area requirements in the Carpathian Mountains.

For the brown bear, the selected edge depths were 4 km (settlements), 3.4 km (national roads, regional roads, railways and cable cars), 700 m (local roads) and 300 m (watercourses) (Ministry of Environment and Forests 2014). For the PROX, we used differential dispersion radius values, adapted to the species body size and home range, such as 25 km for brown bear, 15 km for wild boar and 10 km for red fox (Niculae et al. 2017). Also, since ECON, SHAPE and GYRATE lack parameters adjustable according to the ecological particularities of a certain species, the values returned by these metrics were considered universal for all the three species under study (Botequila et al. 2006). The resulting habitats fragmentation maps were overlaid over the location of HWI hotspots.

Habitat connectivity

We assessed the connectivity of ecological corridors for the three species through the cost connectivity method (Yumnam et al. 2014, Paviolo et al. 2016, DeMatteo et al. 2017). The approach was adequate for our assessment because it identified an optimal network of ecological corridors which connect suitable habitat regions for the wildlife species involved in HWI and quantifies the routes fragmentation using a robust algorithm - the least - cost path analysis, commonly used in ecological modelling. This method also accounted both the restrictive factors (expressed through a cost surface model) and favorable elements (habitat suitability model) which characterized the ecological behaviour of the targeted species. The models also supported an unlimited number of parameters, whereas their complexity can be constantly adjusted, and the models can be species - specific, and therefore developed for each species separately (Osipova et al. 2018, Carter et al. 2020).

Habitat suitability

For each of the three species, we developed a particular habitat suitability model, representing the spatial projection of suitable habitat (Kearney 2006). Each of the three habitat suitability models encompassed another three sub - models (shelter, resources and human security), equally ranked, and developed according to the habitat requirements extracted from the scientific literature (Cristescu et al. 2019, Ruben et al. 2020). Because geomorphology has a crucial influence in the spatial distribution of wildlife species, since it establishes a terrain's potential to offer proper shelter requirements, the wildlife shelter sub - models implicated three continuous geomorphological variables (slope, exposition and altitude variation), derived from the DEM dataset (Bosch et al. 2014).

Our resource sub - models were based on land cover data and included both discrete (land cover classes and potential virgin forests) and continuous (distance to watercourses and river density) variables (Paviolo et al. 2018). We have added the potential virgin forests since they express areas of intact wilderness and low human alteration, which have the potential to offer high - quality resources for wildlife (Măntoiu et al. 2016).

The human security sub models included four continuous anthropogenic variables derived from the land cover data (distance to settlements, distance to roads, settlement density, and road density). These variables express human pressure measures which influence the ecological behaviour of wildlife (Krester et al. 2008, Takahata et al. 2014). The selected variables were transformed onto a common scale (between 1 and10) through the reclassify function (in case of discrete variables), respectively rescale by function (for continuous variables). High values were allocated to the areas considered highly favourable, whereas low values were assessed for regions characterized by low habitat favourability (Store & Jokimaki 2003) (Figure 3).

To identify the optimal wildlife habitat patches within the final suitability models (Brooks 2001, Xia & Gar - On Yeh 2005), for each of the three species, we have introduced the next parameters: brown bear - the total suitable area of 50 km^2 (with patch size varying between 15 and 5 km^2, and dispersion distances of maximum 25 km) (Pop et al. 2012, Popescu et al. 2017); wild boar - 25 km^2 (7.5 - 2.5 km^2, 10 km) (Janoska et al. 2018) and red fox - 10 km^2 (3 - 1 km^2, 5 km) (Weber & Meia 1996, Holmala & Kauhala 2009).

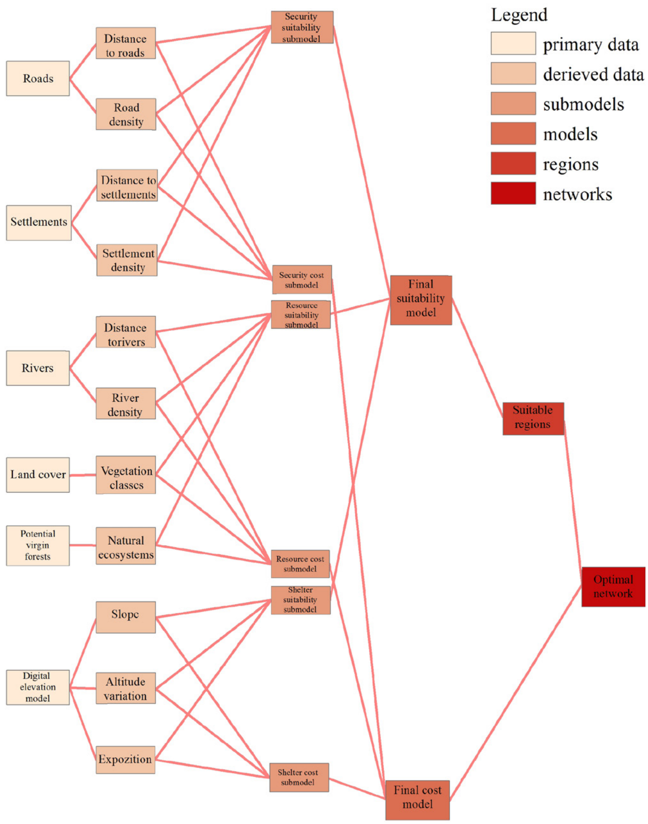

Figure 3 The methodological framework developed for the cost connectivity modelling of the three wildlife species - brown bear, wild boar and red fox, involved in human-wildlife interactions within the settlements of Bușteni, Sinaia and Predeal, from the upper Prahova Valley of Romania, as reported by local citizens between September 2018 and August 2019. Primary data (roads, settlements, rivers, land cover, potential virgin forests and digital elevation model) were derived to variables which influence the species ecological behaviour (distance to settlements, distance to roads, settlement density, road density, distance to watercourses, river density, vegetation classes, natural ecosystems, slope, altitude variation and slope exposition) and used in order to develop three suitability/ cost sub-models (human security, resource and shelter). The suitability sub-models were introduced into a final suitability model, which was used to generate the wildlife suitable regions map. The cost sub-models were merged into a final cost sub-model. The suitable regions map and the cost sub-model was used to develop a network of wildlife optimal ecological corridors.

Cost surface models

As in the case of the suitability models, for each of the three species, we have developed cost surface models, which quantified the expected potential level of ecological stress (Kearney 2006). Our three cost models included the same categories of sub - models (shelter, resources and human security) and derived variables as the suitability ones. The variables were reclassified on the same common scale, but a different rule. In this case, high values were allocated to regions of intense ecological stress, whereas low values were used for regions characterized by suitable conditions (Store & Jokimaki 2003). For each of the species, the cost models were used to develop a network of ecological routes, which connect the suitable habitat regions identified through the suitability models (Yumnam et al. 2014) (Figure 3). Finally, the cost routes and the optimal regions were superimposed over the location of clusters of housing units involved in HWI.

Results

As for the local citizens, the proportion (rate) of the population of each surveyed settlement (intensity of sampling) were 1.4% (Sinaia), 2.03% (Bușteni) and 1.07% (Predeal). 50.2% of the total number of respondents were females and only 49.8% were males. Also, 62.9% of the respondents were employees, whereas 37,1% were retired.

The species commonly involved in HWI are brown bear, wild boar and red fox. For all of them, the metrics indicate that the areas with highly fragmented forest habitats are primarily located in the proximity of human infrastructures and overlap the spatial distribution of the major WHI hotspots. Therefore, the areas of high ecological disturbances lie at the peripheries of settlements. The western periphery of Sinaia (located within the Bucegi Mountains) represents the areas single most important wild boar HWI hotspot, followed by the city of Bușteni (where brown bear interactions are at their peak) and the eastern periphery of Predeal, where red fox descents are frequent (Figure 4).

The total forest core area is 181.2 ha (0.69% of the total landscape area). The mean patch core area summed 0.19 ha and the area - weighted mean is 3.2 ha (median = 0, range = 93.3, stdev = 3.42). Forest patches with small core areas (less than 0.8 ha) summarize 16384 ha (83. 8% from total forest area), while the ones with large core areas (10.1 - 98.4 ha) cover just 432 ha (2.2%). The forest patches with the smallest amount of core area are located especially in the central and eastern part of the study area, where human pressure and HWI are at their highest. The total forest edge contrast index is 38.9%. The mean tips 49.3% while the area - weighted mean is 35.09% (median = 49.8%, range = 100%, stdev = 25.6%). Medium - low and low ECON values (less than 38% edge contrast) were registered by forest patches which cover 12303 ha (62.9% of total forest area). Conversely, medium - large, and large values (higher than 62% edge contrast) characterize only 1083 (5.5%) of the entire forested landscape and were retained by forest patches which lie at the outskirts of all the three major settlements. Patches with complexes shapes (SHAPE >3.14) total 4669 ha (23.8%) and are located mainly in the northern mountains, while 28.1% of the forest area (5503 ha) is represented by patches with medium - high SHAPE values (2.43 - 3.14) and 30.4% (5952 ha) by medium value ones (1.84 - 2.43). Low and medium - low SHAPE value patches (less than 1.84) summarize only 2365 ha (12%). For GYRATE, high values (856.41 - 1517.68) were returned by 48.2% (9423 ha) of the forest patches. Low, medium - low and medium values (2.5 - 500.8) were computed for patches which total only 3473 ha (17.7%) located preponderantly west of Sinaia. In case of the PROX (both 25, 15 and 10 km radius), 70.4% (13757 ha) of the forested landscape is occupied by patches with high and medium - high values (46752 - 161929), while 26.5% (5186 ha) characterizes the areas with low, medium - low and medium ones (34 - 46752). The highest values (93084 - 161929) were recorded by patches within the high mountain areas, while the lowest (34 - 8123) were assigned to forests surrounding Predeal.

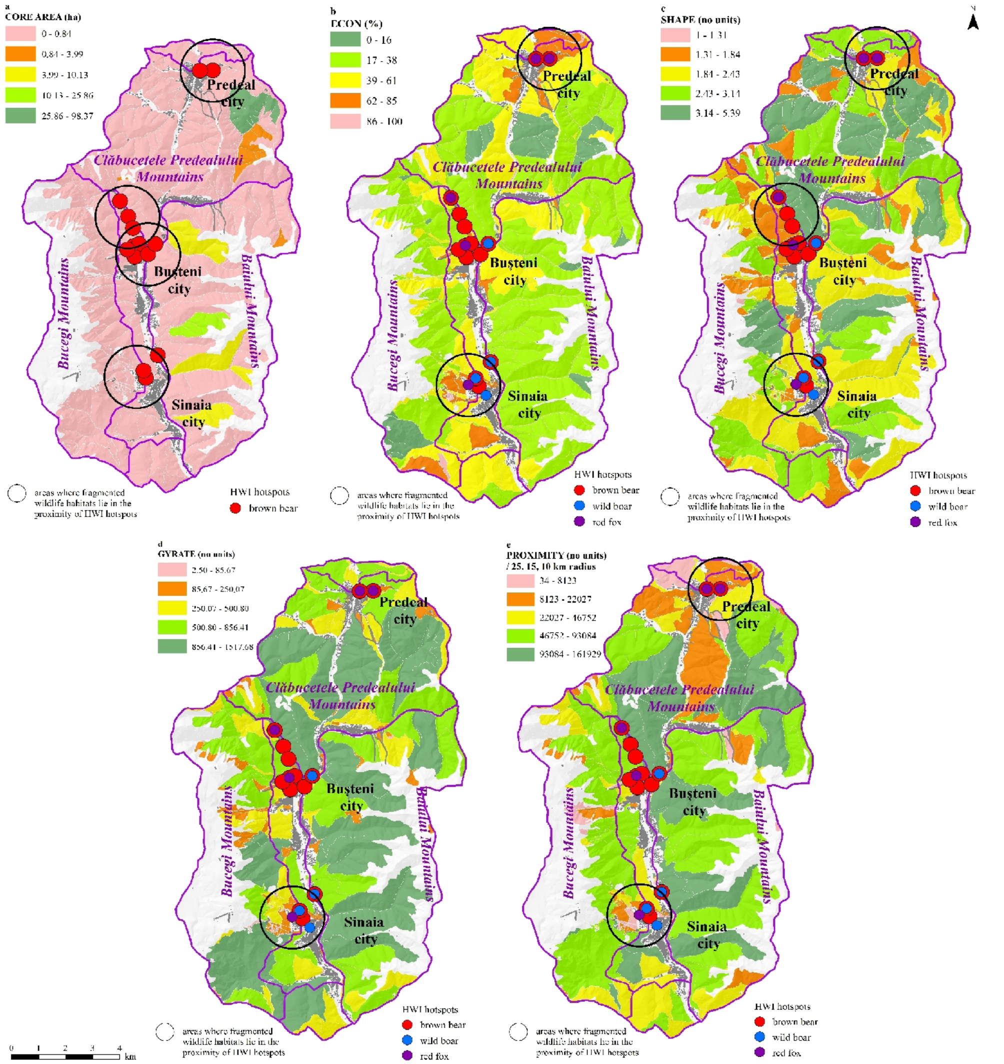

Figure 4 Overlapping of the forests fragmentation maps assessed through the use of landscape metrics at patch level (a – CORE AREA, b – ECON, c – SHAPE, d – GYRATE, e – PROXIMITY 25, 15, 10 m radius) over the human-wildlife interactions hotspots (red–brown bear, blue–wild boar, purple – red fox) within the settlements of Buşteni, Sinaia and Predeal, from the upper Prahova Valley of Romania.

The landscape metrics reveal that the study area possesses efficient wildlife habitat longitudinal connectivity and weak latitudinal one, as an implication of the fragmentation generated by the central chain of transport arteries and settlements. For all the three species, the highest costs optimal paths are the ones which intersect the areas major transport infrastructures, and simultaneously, are located in the proximity of the outskirts of the settlement with the most intense HWI phenomenon (Figure 5).

The overall brown bear optimal habitat patches area is 5008 ha (mean = 626, stdev = 108.31), representing 19.2% of the total landscape. We have modelled optimal habitat patches varying in size between 500 and 750 ha, disposed on both sides of the central valley, where the major human infrastructures lie.

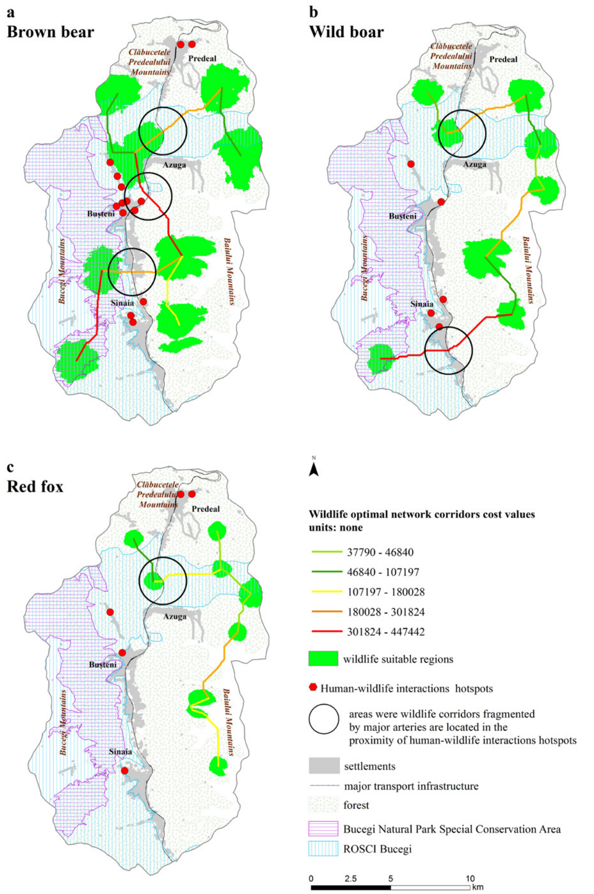

Figure 5 Overlapping of the cost connectivity models, which include suitable regions and optimal network of corridors cost values, over the human-wildlife interactions hotspots (a – a brown bear, b – wild boar, c – red fox) within the settlements of Bușteni, Sinaia and Predeal, from the upper Prahova Valley of Romania.

Only two patches (located in Clăbucetele Predealului and Baiului Mountains) are the only ones which represent connecting nodes for three routes, whereas, in Bucegi Mountains, the most important patch for bear movement connects only two routes. Seven routes were identified, the most expensive (value = 344534) being the one connecting habitat patches on latitudinal directions, intersecting railway and national highway, and lying in the proximity of several major brown bear HWI hotspots. Therefore, the largest and most important brown bear optimal habitat patches are connected by an optimal network path which represents the main latitudinal passing corridor, and which, complementary, scored a high - cost value, since it intersects major transport arteries. Furthermore, this major brown bear passing corridor lies alongside the outskirts of Bucegi city (a major HWI hotspot with the most intense interaction between brown bears and local citizens from the entire study area) (Table 3).

For the wild boar, the optimal patches have a similar location with the brown bear, and a total area of just 2506 ha (mean = 313.25, stdev = 103.34). For the fox, the overall optimal patches area equal even less (total area = 1004 ha, mean = 125.5, stdev = 43.6). The patch size varies between 250 and 560 ha (wild boar), respectively between 100 and 200 ha (red fox). For both species, the number of habitat patches within the Bucegi Mountains is scarcer than in case of the brown bear (only one patch for the wild boar and none for the red fox). Moreover, the Sinaia city centre (where wild boar presence is the highest within the entire study area) is located at just 1.5 km south of the wild boar single most important pathway which connects the two major optimal habitat patches within the Bucegi and Baiului Mountains. The patch is characterized by a very high - cost value (447442) due to the fragmentation of regional infrastructure. In the case of the red fox, the connectivity of ecological corridors does not seem to be so severely affected (highest scored value = 301824) (Table 3).

Our results validated our study hypothesis that HWI hotspots were in areas where wildlife habitats were fragmented, and ecological corridors poorly connected due to human infrastructures. Overall, the landscape metrics indicate that the study areas wildlife habitats

Table 3 Statistics of the suitable habitat regions areas and optimal corridors cost values, modelled according to the cost connectivity approach, for the species implicated in human-wildlife interactions - brown bear, wild boar and red fox, within the settlements of Bușteni, Sinaia and Predeal, from the upper Prahova Valley of Romania, as reported by local citizens between September 2018 and August 2019.

Wildlife	Sum	Mean	Standard deviation	Median	Maximum	Minimum
Optimal corridors values (no units)						
Brown bear	1442962	206137	98015	233854	344534	94776
Wild boar	1131230	161604	132914	123418	447442	39727
Red fox	666818	95259	58013	73062	201528	37790
Suitable habitat regions areas (ha)						
Brown bear	5008	626	108	628	756	496
Wild boar	2506	313	103	251	562	250
Red fox	1004	125	44	101	201	99

are fragmented in terms of core area and edge functionality in the central region, where the settlements are located. Over 80% of the study area encompasses forest patches with a potential brown bear core area of less than 0.84 ha, which is considerably smaller than the ones normally required by the species in the eastern range, where median values range between 550 and 3500 ha (Popescu et al. 2017, Pop et al. 2018). Similarly, the overall forest patch fragmentation indicates potential edge dysfunctions especially in the central area, where the settlements and major roads lie (over 40% edge contrast), since the mean edge length shared with a road, or artificial areas is close to half (50%) of the forest patch perimeter. In case of patch connectivity, the model suggests that for all the three species, wildlife movement is efficient only on longitudinal directions due to large, compact and close together patches which are fragmented only by touristic tracks, and reduced on the latitudinal ones, due to the dense central area's settlement concentration and major arteries.

By overlapping the spatial distribution of HWI hotspots with our models regarding fragmentation of wildlife habitats and ecological corridors, the results indicate that wildlife disturbance generated by anthropic infrastructures could potentially influence the distribution of HWI. Our results highlight that within the upper Prahova valley, the largest optimal wildlife patches do not benefit by any form of preservation and the latitudinal wildlife connectivity between these patches is affected by the fragmentation of longitudinal major transport arteries. Consequently, for all the three species, the highest costs ecological corridors are the ones which intersect the areas major transport infrastructures, and simultaneously, are in the proximity of the settlements with the most intense HWI phenomenon. These are also the areas where forest habitats are severely fragmented.

Discussion

The results of our study fit partially with other assessments on forest patches fragmentation and connectivity, which certified that at the national scale, the patches within the Bucegi and Baiului Mountains are well connected, but only for species with large body mass and long dispersion distances (Niculae et al. 2017). Also, our models convey with the ones of Malviya and Ramesh (2015), who identified the fact that large felids in Nepal are likely to be involved in HWI when they access wildlife corridors in highly fragmented landscapes. Similarly, Neelakantan et al. (2019) suggests that in India, numerous households face higher HWI risk due to their location in the proximity of wildlife corridors which connect increasingly fragmented habitats and insular protected areas. Consequently, managing continued human activity and fragmentation of wildlife corridors was assessed as one of the main challenges faced by the local authorities in Alberta, Canada, for improving Human-Wildlife coexistence (Human-Wildlife Coexistence Bow Valley Report 2018).

Our assessment addresses the gap represented by the lack of studies concerning the influence on landscape fragmentation on HWI and uses as a pilot area the Prahova Upper Valley from the Carpathian region of Romania, known for the intensity of wildlife descents in human settlements. In Romania, numerous studies were dedicated to analysing the habitat requirements of large predatory mammals, followed by their behaviour regarding the potential of response to human pressure and habitat alteration (Pop et al. 2012, Popescu et al. 2017, Sin et al. 2019). Besides, the HWI phenomenon was explained mainly through ineffective large - scale wildlife management or precarious interest of the authorities implicated in forest administration (Rozylowicz et al. 2011, Ionescu 2016, Popescu et al. 2016). In the western Carpathians, only Goldthorpe (2017) addressed the importance of diminishing habitat fragmentation and enhancing corridors connectivity for brown bear and grey wolf to prevent damage on livestock and conflicts with shepherds based on a regional network of protected areas.

Worldwide, the implementation and preservation of corridors connecting wildlife protected areas are proposed for decreasing the impacts of human settlements that fragment habitats and favour HWI involving elephants in eastern Africa (Kikoti et al. 2011, Chlebek and Stalter 2015, Adams et al. 2017). Similarly, the importance of studying wildlife habitat fragmentation for a better HWI management has been explored by Proctor et al. (2018) in northern Montana and Idaho, USA, who proposes the reduction of human activity and fragmentation of wildlife corridors, to lower the magnitude of interactions. The enhancement of sustainable livelihoods of rural communities scattered in the proximity of fragmented wildlife corridors is expected to be a major contributor to the reduction of problematic interactions with wildlife in Uganda (Wildlife Conservation Society 2008). Similarly, Cushman et al. (2018) suggest that the most efficient approach to preserve large carnivore population in Botswana is to maintain the network of protected areas, protect wildlife corridors and strengthen measures in HWI hotspots, whereas Atwood and Breck (2012) proposes a framework that integrates ecological landscape data of habitat fragmentation and connecting corridors, respectively sociological information to better understand and administrate conflicts with black bear (*Ursus americanus*) in Arizona, USA.

Assessing the effect of habitat fragmentation on HWI is crucial in understanding and efficiently managing conflicts between human and wild animals in human - dominated landscapes (Dorresteijn 2015). Landscape metrics represent a proper tool, usable to quantify the degree of ecological functionality in landscapes which support wildlife habitats and highlight healthy ecosystems, or conversely, degraded areas characterized by potential ecological malfunctions (Botequila et al. 2006). Our results indicate that this approach helps us to improve the understanding of HWI driving forces by considering, besides common intensively studied aspects (such as poor collaboration between institutions with decisional power or ineffective forest staff management practices) (Popescu et al. 2016), other potential triggering factors, represented by local scale landscape fragmentation induced by settlements, touristic trails and major transport infrastructures. Against the absence of field data, fragmentation maps may reveal other hidden areas which are suitable candidates for HWI manifestation, and which require rigorous management. The cost connectivity approach helps us identify the largest optimal wildlife habitat patches and by evaluating their conservation status, we could pinpoint potentially rich - biodiversity areas, which are unprotected and where urgent conservation is required. The models indicate the stepping point's which are proper candidates for future implementation of wildlife micro - corridors, suitable for enhancing the local species movement and potentially reduce the HWI magnitude in settlements (Paviolo et al. 2016, DeMatteo et al. 2017). By applying questionnaires to local citizens, we were able to collect data regarding the main wildlife species involved in conflicts, and based on their perception, we could estimate the HWI frequency, expressed in a number of the day when wildlife occurred in settlements per year (Mponzi et al. 2014, Can - Hernandez et al. 2019). By mapping the spatial distribution of HWI frequency data expressed by locals, we have identified the prime conflict hotspots. Together with GIS techniques, this information could help local authorities to analyse the expansion of wildlife descents into settlements and develop predictions regarding other anthropic areas which based on their spatial characteristics (such as location in the proximity of fragmented habitats) could represent attraction spots for wild animals.

The utility of using FRAGSTATS to assess forest habitat fragmentation is hampered by two major limitations. First, the metrics are sensitive to data resolution and the software is dependent on discrete land cover raster data and does not compute statistics on vector spatial data. Therefore, when converting a vector data set into a raster, if the minimum size of the narrowest patch from the vector image is smaller than the raster cell size (as in the case of linear land cover classes, such as roads or rivers), there is the possibility that a single vector patch to be converted into numerous raster patches with the size of one cell, and this error may mislead the results of the further statistics (Kupfer 2012). Second, the ecological relevance of FRAGSTATS metrics is affected by the potential disconnections between landscape pattern and ecological functions and processes. Metrics are developed to indicate only the expected potential level of ecological functionality characterizing a specific landscape (Botequila et al. 2006). By consequence, the connections between metrics and ecological processes may be misled by the influences of other landscape features. As an example, assessing the impact of habitat configuration through landscape metrics on biotic resources is hampered by the implications of habitat extend (Wang & Cumming 2011), whereas the ecological significance of metrics results is distorted by the challenges of modelling large - scale processes and the weak response to dynamics in landscape - scale and configuration (Li & Wu 2004). Overall, the most sensible limitation concerning FRAGSTATS metrics is that they are much more focused on landscape structure and configuration, rather than on the landscape's functional implications (Kupfer 2012).

The development of cost connectivity models included several minor aspects which in the future could be enhanced. First, we have encountered a lack of detailed spatial data concerning wildlife ecological requirements within the study area, such as areas with dense, consistent food resources or ecological corridors, followed by the absence of forest management spatial information, namely wildlife feeding or observation points. Second, the efforts allocated to develop habitat suitability and cost models were hampered by the lack of scientific information before the values of the environmental parameters required by the generalist non - protected and non - charismatic wildlife species within the Carpathian range in Romania, such as wild boar or red fox.

The process of collecting self - reported data from local citizens was embedded due to several biases. The first is represented by their lack of interest concerning the subject, and materialized in inconsistent answers, which were insufficient for our goal and constrained us to request supplementary information. Second, in several cases, our assessment was hampered by their reluctance and mistrust regarding our intentions, and therefore, we have noticed evasive and vague responds. Thirdly, some respondents expressed feelings of revolt against the local authorities' lack of will and precarious management of the HWI problem, materialized in superficial responses and justified by the fact that the authorities are expected not to consider or exploit the results of our research.

Conclusions

In this study, we have quantified the landscape spatial characteristics in the upper Prahova valley of Romania and mapped the distribution of Human-Wildlife interaction (HWI) to highlight how habitat fragmentation determines the occurrence of these interactions. We have modelled the fragmentation of wildlife habitats and ecological routes for brown bear, wild boar and red fox, and overlaid the maps of interaction hotspots to identify and characterize areas of intense conflicts.

Our study's main contributions and significant findings reveal that: i) landscape fragmentation has the potential to represent a major driving factor for the spatial distribution and intensity of HWI; ii) exploring local citizens perception about HWI proves a useful approach to identify potential driving forces of HWI; iii) using models regarding optimal networks corridors can indicate areas of high conservation values and healthy habitats with the potential to support rich biodiversity, or by the opposite, ecosystem malfunctions induced by anthropic pressure.

The results practical transferability highlights the need for a better collaboration between the major entities taking part in managing HWI in mountain areas, such as local authorities, researches, tourist and locals (Pătru - Stupariu et al. 2020). Local authorities must develop campaigns to warn locals concerning the risks involved by interactions with animals. Tourists must be educated to give up feeding wild animals, respectively to get actively involved in waste management. These practices, properly performed, will reduce the chances of habituation among wild animals. Researchers must analyze and identify the hotspots where human pressure over wildlife habitats favors ecological disturbances. Secondly, they must map the areas characterized by high ecological value and suitable wildlife habitats, and develop wildlife passing corridors which connect these areas, by avoiding the major roads and dense touristic areas. If the ecological corridors intersect large traffic arteries, it is necessary for the authorities to allocate investments in the construction of viaducts that allow the movement of large animals. Also, the authorities should improve the management plans of protected areas, in order to regulate the development of human infrastructures and to minimize the fragmentation of wildlife habitats. Despite the fact that the areas occupied by buildings and roads are located, especially, at the outskirts of the natural park, or in the so - called sustainable management areas, the infrastructure fragmentation affects the connectivity of wildlife species which have their primal habitat in integral protection and strict protection areas. Therefore, it is recommended to develop large buffer zones around valuable natural areas, and to minimize the expansion of human infrastructures in the proximity of high - quality wildlife habitats.

In terms of future perspectives, the present research could pave the way for further studies, focusing on the importance of developing management plans concerning protected areas which shelter wildlife, by considering, as crucial variables, the level of landscape fragmentation and presence of potential driving forces for HWI. Second, the results draw attention to the need to develop a more in - depth perspective regarding the potential of durable natural resource management and sustainable spatial planning for optimizing the interaction between wildlife and human in shared habitats. Lastly, in contrast to the results of our study, new spatial analyses can be developed in the future to assess other effects of landscape connectivity on HWI, such as the possibility of wildlife attraction in anthropogenic areas, if habitats located near settlements benefit from a high density of intact ecological corridors.

Compliance with ethical standards

Conflict of interest

Authors declare there is no conflict of interest.

Acknowledgments

The "Simion Mehedinți" Doctoral School from the Faculty of Geography, University of Bucharest, provided financial support.

References

Adams T.S., Chase M.J., Rogers T.L, Leggett K.E., 2017. Taking the elephant out of the room and into the corridor: can urban corridors work? Oryx 51(2): 347-353. https://doi.org/10.1017/S0030605315001246

Amit R., Gordillo-Chávez E.J., Bone R., 2013. Jaguar and puma attacks on livestock in Costa Rica. Human-Wildlife Interactions 7(1): 77-84. https://doi.org/10.26077/885q-4818

Atwood T.C., Breck S.W., 2012. Carnivores, conflict, and conservation: defining the landscape of conflict. In: Álvares F.I., Guilherme E.M., (ed.), Carnivores: Species, Conservation, and Management. Nova Science Publishers University of Nebraska, Lincoln: pp. 98-118.

Baldwin R.A., Bender L.C., 2009. Survival and productivity of a low-density black bear population in Rocky Mountain National Park, Colorado. Human-Wildlife Interactions 3(2): 271-281. https://doi.org/10.26077/52v3-7z08

Basak S.M., Hossain S., Okarma H., Widera E., Wierzbowska I., 2022. Public perceptions and attitudes toward urban wildlife encounters-A decade of change. The Science of The Total Environment 834: 155603. https://doi.org/10.1016/j.scitotenv.2022.155603

Beasley J.C., Rhodes O.E., 2008. Relationship between raccoon abundance and crop damage. Human-Wildlife Interactions 2(2): 248-259. https://doi.org/10.26077/g4bp-bd34

Bennett N.J., Roth R., Klain S.C., Chan K.M.A., Clark D.A., Cullman G., Epstein G., Nelson M.P., Stedman R., Teel T.L., Thomas R.E.W., Wyborn C., Curran D., Greenberg A., Sandlos J., Verissimo. D., 2016. Mainstreaming the social sciences in conservation. Conservation Biology 31(1): 56-66. https://doi.org/10.1111/cobi.12788

Biset A., Mengesha G., Girma Z., 2019. Human-wildlife conflict in and around Borena Sayint National Park, Northern Ethiopia. Human-Wildlife Interactions 13(1): 111-124. https://doi.org/10.26076/fk60-mp27

Borah J., Bora P.J., Sharma A., Dey S., Sarmah A., Vasu N.K., Sidhu N., 2018. Livestock depredation by Bengal tigers at fringe areas of Kaziranga Tiger Reserve, Assam, India: Implications for Large Carnivore Conservation. Human-Wildlife Interactions 12(2): 186-197. https://doi.org/10.26077/zh6v-pk64

Bosch J., De la Torrre A., Alexandrov T., Martín I.I., Miteva A., Muñoz J.M., 2014. Can habitat suitability predict the presence of wild boar? Suitable land uses vs. georeferenced data in Bulgaria. Journal of Vertebrate Biology 63(3): 194-205. https://doi.org/10.25225/fozo.v63.i3.a7.2014

Botequilha L.A., Ahern J., 2002. Applying landscape ecological concepts and metrics in sustainable landscape planning. Landscape and Urban Planning 59(2): 65-93. https://doi.org/10.1016/S0169-2046(02)00005-1

Botequilha L.A., Miller J., Ahern J., McGarigal K., 2006. Measuring landscapes: a planner's handbook. Island Press, Washington DC. 272 p.

Bow Valley Human-Wildlife Coexistence Technical Working Group 2018. Recommendations for Improving Human-Wildlife Coexistence in the Bow Valley. 86 p.

Brook R.K., 2009. Historical review of elk-agriculture conflicts in and around Riding Mountain National Park, Manitoba, Canada. Human-Wildlife Interactions 3(1): 72-87. https://doi.org/10.26077/2q3d-k002

Brooks C.J., 2001. A genetic algorithm for designing optimal patch configurations in GIS. International Journal of Geographical Information Science 15(6): 539-559. https://doi.org/10.1080/13658810131690722 7

Cagnacci F., Alberto M., Lovari S., 2004. Habitat selection by the red fox "*Vulpes vulpes*" (L. 1758) in an Alpine area. Ethology Ecology & Evolution 16(2): 103-116. https://doi.org/10.1080/08927014.2004.9522640

Can-Hernández G., Villanueva-García C., Gordillo-Chávez E.J., Pacheco-Figueroa C.J., Pérez-Netzahual E., García-Morales R., 2019. Wildlife damage to crops adjacent to a protected area in southeastern Mexico: farmers' perceptions versus actual impact. Human-Wildlife Interactions 13(3): 423-438. https://doi.org/10.26077/9gqj-5m75

Carter N., Williamson M.A., Gilbert S., Lischka S.A., Prugh L.R., Lawler J.J., Metcalf A.L., Jacob A.L., Beltrán B.J., Castro J.A., Sage A., Burnham M., 2020. Integrated spatial analysis for Human-Wildlife coexistence in the American West. Environmental Research Letters 15: 021001. https://doi.org/10.1088/1748-9326/ab60e1

Chen X., Wu S., 2014. Examining patterns of animal-vehicle collisions in Alabama, USA. Human-Wildlife Interactions 8(2): 235-244. https://doi.org/10.26077/p18k-1089

Chlebek N., Stalter L., 2015. Tracking the elephant (*Lexodonta africana*) corridor and the human-wildlife conflict in Selela Village. Independent Study Project (ISP) Collection 2046.

Cimpoca A.L., Voiculescu M., Crețan R., Ianăș A.N., Voiculescu S., 2024. Living with bears in Prahova Valley, Romania: An integrative analysis. Animals 14(4): 587. https://doi.org/10.3390/ani14040587

Cimpoca A.L., Voiculescu M., 2022. Patterns of human-brown bear conflict in the urban area of Brașov, Romania. Sustainability 14(13): 7833. https://doi.org/10.3390/su14137833

Conover M.R., 2019. Numbers of human fatalities, injuries, and illnesses in the United States due to wildlife. Human-Wildlife Interactions 13(2): 264-276. https://doi.org/10.26077/r59n-bv76

Cristescu B., Domokos C., Teichman K.J., Nielsen S.E., 2019. Large carnivore habitat suitability modelling for Romania and associated predictions for protected areas. PeerJ 7:e6549. https://doi.org/10.7717/peerj.6549

Csorba P., Szabo S., 2012. The Application of Landscape Indices in Landscape Ecology. In: Tiefenbacher J., (ed.), Perspectives on Nature Conservation-Patterns, Pressures and Prospects. InTech, Rijeka: pp. 121-141.

Cushman S.A., McGarigal K., Neel M.C., 2008.

Parsimony in landscape metrics: strength, universality, and consistency. Ecological Indicators 8(5): 691-703. https://doi.org/10.1016/j.ecolind.2007.12.002

Cushman S.A., Elliot N.B., Bauer D., Kesch K., Bahaa-El-Din L., Bothwell H., Flyman M., Mtare G., Macdonald D.W., Loveridge A.J., 2018. Prioritizing core areas, corridors and conflict hotspots for lion conservation in southern Africa. PloS One 13: e0196213. https://doi.org/10.1371/journal.pone.0196213

DeMatteo K.E., Rinas M.A., Zurano J.P., Selleski N., Schneider R.G., Argu¨elles C.F., 2017. Using niche-modelling and species-specific cost analyses to determine a multispecies corridor in a fragmented landscape. PLoS One 12: e0183648. https://doi.org/10.1371/journal. pone.0183648

DeVault T.L., Beasley J.C., Humberg L.A., MacGowan B.J., Retamosa M.I., Rhodes O.E., 2007. Intrafield patterns of wildlife damage to corn and soybeans in Northern Indiana. Human-Wildlife Interactions 1(2): 205-213. https://doi.org/10.26077/0j2d-d311

Dorresteijn I., Milcu A.I., Leventon J., Hanspach J., Fischer J., 2015. Social factors mediating human-carnivore coexistence: Understanding thematic strands influencing coexistence in Central Romania. Ambio 45: 490-500. https://doi.org/10.1007/s13280-015-0760-7

European Environmental Agency 2017. Digital Elevation Model over Europe (EU-DEM). Web: https://www.eea.europa.eu/data-and-maps/data/eu-dem. Accesed: 05.02.2020.

Fedorca A., Popa M., Jurj R., Ionescu G., Ionescu O., Fedorca M., 2020. Assessing the regional landscape connectivity for multispecies to coordinate on-the-ground needs for mitigating linear infrastructure impact in Brasov-Prahova region. Journal for Nature Conservation 58: 125903. https://doi.org/10.1016/j.jnc.2020.125903

Fedorca A., Russo I.R.M., Ionescu O., Ionescu G., Popa M., Fedorca M., Curtu A.L., Sofletea N., Tabor G.M., Bruford M.W., 2019. Inferring fine-scale spatial structure of the brown bear (*Ursus arctos*) population in the Carpathians prior to infrastructure development. Scientific Reports 9: 9494. https://doi.org/10.1038/s41598-019-45999-y

Frank B., 2015. Human-Wildlife conflicts and the need to include tolerance and coexistence: an introductory comment. Society and Natural Resources 29(6): 738-743. https://doi.org/10.1080/08941920.2015.1103388

Gilleland A.H., 2010. Human-Wildlife Conflict across Urbanization Gradients: Spatial, Social, and Ecological Factors. PhD thesis, University of South Florida, Miami. 165 p.

Giuliano D., Battisti A., Bassano B., 2019. Feeding ecology of the red fox in the Soana Valley, Gran Paradiso National Park. Journal of Mountain Ecology 12: 1-18. http://www.mountainecology.org/index.php/me/article/view/216

Goldthorpe G., 2017. A Human-Wildlife conflict mitigation toolkit. EU LIFE+ project, Enhancing Landscape Connectivity for Brown Bear and Wolf through a Regional Network of NATURA 2000 Sites in Romania, LIFE Connect Carpathians LIFE12 NAT/UK/001068. 102 p.

Greenpeace Romania 2017. Potential Primary Forests Map of Romania. Web: https://www.greenpeace.org>. Accesed 05.02.2020.

Griffin L.L., Ciuti S., 2023. Should we feed wildlife? A call for further research into this recreational activity. Conservation Science and Practice 5(7): e12958. https://doi.org/10.1111/csp2.12958

Holmala K., Kauhala K., 2009. Habitat use of medium sized carnivores in southeast Finland - key habitats for rabies spread? Annales Zoologici Fennici 46(4): 233-246. https://doi.org/10.5735/086.046.0401

Huguenin Jr M.A., 2015. Trends in Human-Wildlife Interactions as Related to Land Use and Human Density in Massachusetts. Dissertation, University of Massachusetts, Boston. 82 p.

Hull V., Bian X., Sturgeon D.J.E., Rivera C.J., Rojas Bonzi V.B., Morzillo A.T., 2023. Living with wildlife: a review of advances in social-ecological analysis across landscapes. Landscape Ecology 38(12): 4385-4402. https://doi.org/10.1007/s10980-023-01778-9

Huntuș A.C., 2016. Study on tourism planning in Prahova county by tourist traffic analysis. Scientific Papers. Series Management, Economic Engineering in Agriculture and Rural Development 16: 197-204.

Ionescu O., 2016. Managementul carnivorelor mari în România. Abilitation thesis, University of Transylvania, Brașov. 102 p.

Janoska F., Farkas A., Marosan M., Fodor J.T., 2018. Wild Boar (*Sus scrofa*) Home Range and Habitat Use in Two Romanian Habitats. Acta Silvatica et Lignaria Hungarica 14: 51-63. https://doi.org/10.2478/aslh-2018-0003

Joshi R., Puri K., 2019. Train-elephant collisions in a biodiversity-rich landscape: A case study from Rajaji National Park, North India. Human-Wildlife Interactions 13(3): 370-381. https://doi.org/10.26077/88bc-qm70

Kala C.P., Kothari K.K., 2013. Livestock predation by common leopard in Binsar Wildlife Sanctuary, India: Human-Wildlife conflicts and conservation issues. Human-Wildlife Interactions 7(2): 325-333. https://doi.org/10.26077/c366-ej10

Kamler J., Dobrovolný L., Drimaj J., Kadavý J., Kneifl M., Adamec Z., Knott R., Martiník A., Plhal R., Zeman J., Hrbek J., 2016. The impact of seed predation and browsing on natural sessile oak regeneration under different light conditions in an over-aged coppice stand. iForest 9(4): 569-576. https://doi.org/10.3832/ifor1835-009

Kearney M., 2006. Habitat, environment and niche: what are we modelling? Oikos 115(1): 186-191. https://doi.org/10.1111/j.2006.0030-1299.14908.x

Khorozyan I., Heurich M., 2022. Large-scale sheep losses to wolves (*Canis lupus*) in Germany are related to the expansion of the wolf population but not to increasing wolf numbers. Frontiers in Ecology and Evolution 10: 778917. https://doi.org/10.3389/fevo.2022.778917

Kikoti A., Griffin C.R., Pamphil L., 2011. Elephant use and conflict leads to Tanzania's first wildlife conservation corridor. Pachyderm 48: 57-66.

KimY., Chol S., Choung Y., 2019. Habitat preference of wild boar (*Sus scrofa*) for feeding in cool-temperate forests. Journal of Ecology and The Natural Environment 43: 30. https://doi.org/10.1186/s41610-019-0126-3

Konig H., Kiffner C., Kramer-Schadt S., Fürst C., Keuling O., Ford A.T., 2020. Human-Wildlife coexistence in a changing world. Conservation Biology 34(4): 786-794. https://doi.org/10.1111/cobi.13513

Krester H.E., Sullivan P.J., Knuth B.A., 2008. Housing density as an indicator of spatial patterns of reported Human-Wildlife interactions in northern New York. Landscape and Urban Planning 84(3-4): 282-292. https://doi.org/10.1016/j.landurbplan.2007.08.007

Kubala J., Gregorová E., Smolko P., Klinga1 P., Iľko T., Kaňuch P., 2020. The coat pattern in the Carpathian population of Eurasian lynx has changed: a sign of demographic bottleneck and limited connectivity. European Journal for Wildlife Research 66: 2. https://doi.org/10.1007/s10344-019-1338-7

Kupfer J.A., 2012. Landscape ecology and biogeography: Rethinking landscape metrics in a post-FRAGSTATS landscape. Progress in Physical Geography 36(3): 400-420. https://doi.org/10.1177/0309133312439594

Li H.B.,Wu J.G.., 2004. Use and misuse of landscape indices. Landscape Ecology 19: 389-399. https://doi.org/10.1023/B:LAND.0000030441.15628.d6

Malviya M., Ramesh K., 2015. Human-felid conflict in corridor habitats: Implications for tiger and leopard conservation in Terai Arc Landscape, India. Human-Wildlife Interactions 9(1): 48-57. https://doi.org/10.26077/x9tx-gb97

Manfredo M.J., Teel T.L., Don Carlos A.W., Sullivan L., Bright A.D., Dietsch A.M., Bruskotter J., Fulton D., 2020. The changing sociocultural context of wildlife conservation. Conservation Biology 34(6): 1549-1559. https://doi.org/10.1111/cobi.13493

Marchini S., Crawshaw P.G., 2015. Human-Wildlife conflict in Brazil: A fast-growing issue. Human-Wildlife Interactions 20(4): 323-328. https://doi.org/10.1080/10871209.2015.1004145

Măntoiu D.S., Nistorescu M.C., Şandric I.C., Mirea I.C., Hăgătiş A., Stanciu E., 2016. Wilderness Areas in Romania: A Case Study on the South Western Carpathians. In: Carver S.J., Fritz S., (ed.), Mapping Wilderness. Springer Dordrecht, Heidelberg: pp 145-156.

McDonald L.R., Messmer T.A., Guttery M.R., 2019. Temporal variation of moose-vehicle collisions in Alaska. Human-Wildlife Interactions 13(3): 382-393. https://doi.org/10.26077/4j2e-3j12

McGarigal K., Marks B., 1995. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland. 122 p.

Messmer T.A., 2000. The emergence of Human-Wildlife conflict management: turning challenges into opportunities. International Biodeterioration & Biodegradation 45(3-4): 97-102. https://doi.org/10.1016/S0964-8305(00)00045-7

Messmer T.A., 2009. Human-Wildlife conflicts: emerging challenges and opportunities. Human-Wildlife Conflicts 3: 10-17.

Michalski F., Boulhosa R.L.P., Faria A., Peres C.A., 2006. Human-Wildlife conflicts in a fragmented Amazonian forest landscape: determinants of large felid depredation on livestock. Animal Conservation 9(2): 179-188. https://doi.org/10.1111/j.1469-1795.2006.00025.x

Ministry of Environment and Forests 2014. Raport științific privind influența schimbărilor climatice asupra somnului de iarnă a ursului brun. 27 p.

Morzillo A.T., De Beurs K.M., Martin-Mikle C.J., 2014. A conceptual framework to evaluate Human-Wildlife interactions within coupled human and natural systems. Ecology and Society 19(3): 44. https://doi.org/10.5751/ES-06883-190344

Mponzi B.P., Lepczyk C.A., Kissui B.M., 2014. Characteristics and Distribution of Live-Stock Losses Caused by Wild Carnivores in Maasai Steppe of Northern Tanzania. Human-Wildlife Interactions 8(2): 218-227. https://doi.org/10.26077/ydcm-0b38

Mustățea M., Pătru-Stupariu I., 2021. Using Landscape Change analysis and Stakeholder Perspective to Identify Driving Forces of Human-Wildlife Interactions. Land 10(2): 146. https://doi.org/10.3390/land10020146

Neagu A.C., Manolache S., Rozylowicz L., 2022. The drums of war are beating louder: Media coverage of brown bears in Romania. Nature Conservation 50: 65-84. https://doi.org/10.3897/natureconservation.50.86019

Neel M., McGarigal K., Cushmn S., 2004. Behavior of class-level landscape metrics across gradients of class aggregation and area. Landscape Ecology 19: 435-455. https://doi.org/10.1023/B:LAND.0000030521.19856.cb

Neelakantan A., DeFries R., Krishnamurthy R., 2019. Resettlement and landscape-level conservation: Corridors, Human-Wildlife conflict, and forest use in Central India. Biological Conservation 232: 142-151. https://doi.org/10.1016/j.biocon.2019.01.033

Niculae M.I., Avram S., Vânău G.O., Pătroescu M., 2017. Effectiveness of Natura 2000 network in Romanian Alpine Biogeographical Region: an assessment based on forest landscape connectivity. Annals of Forest Research 60(1): 19-32. https://doi.org/10.15287/afr.2016.793

Nyhus P.J., 2016. Human-Wildlife conflict and coexistence. Annual Review of Environment and Resources 41: 143-171. https://doi.org/10.1146/annurev-environ-110615-085634

Open Street Map 2020. Open Street Map Data. Web: https://www.openstreetmap.org. Accesed 05.02.2020

Osipova L., Okello M.M., Njumbi S.J., Ngene S., Western D., Hayward M.W., Balkenhol N., 2018. Fencing solves Human-Wildlife conflict locally but shifts problems elsewhere: A case study using functional connectivity modelling of the African elephant. Journal of Applied Ecology 55(6): 2673-2684. https://doi.org/10.1111/1365-2664.13246

Paviolo A., DeAngelo C., Ferraz K.M.P.M.B., Morato R.G., Pardo J.M., Srbek-Araujo A.C., Beisiege B., Lima F., Sana D., Xavier da Silva M., Velázquez M.C., Cullen L., Crawshaw Jr C., Jorge M.L.S.P., Galetti P.M., Di Bitetti M.S., Cunha de Paula R., Eizirik E., Aide T.M., Cruz P., Perilli M.L.L., Souza A.S.M.C., Quiroga V., Nakano E., Pinto F.R., Fernández S., Costa S., Moraes Jr E.A., Azevedo F., 2016. A biodiversity hotspot losing its top predator: The challenge of jaguar conservation in the Atlantic Forest of South America. Scientific Reports 6: 37147. https://doi.org/10.1038/srep37147

Paviolo A., Cruza P., Iezzia M.E., Pardoa J.M., Varelaa D., De Angeloa C., Benito S., Vanderhoeven E., Palacioa L., Quirogaa V., Arrabalb J.P., Costaa S., Di Bitetti M.S., 2018. Barriers, corridors or suitable habitat? Effect of monoculture tree plantations on the habitat use and prey availability for jaguars and pumas in the Atlantic Forest. Forest Ecology and Management 430: 576-586. https://doi.org/10.1016/j.foreco.2018.08.029

Pătru-Stupariu I., Stupariu M.S., Cuculici R., Huzui A., 2011. Understanding landscape change using historical maps. Case study Sinaia, Romania. Journal of Maps 7: 206-220. https://doi.org/10.4113/jom.2011.1151

Pătru-Stupariu I., Angelstam P., Elbakidze M., Huzui A., Andersson K., 2013. Using spatial patterns and forest history to identify potential high conservation value forests in Romania. Biodiversity Conservation 22: 2023-2039. https://doi.org/10.1007/s10531-013-0523-3

Pătru-Stupariu I., Stupariu M.S., Tudor C.A., Grădinaru S.R., Gavrilidis A., Kienas F., Hersperger A.M., 2015. Landscape fragmentation in Romania's Southern Carpathians: Testing a European assessment with local data. Landscape and Urban Planning 143: 1-8. https://doi.org/10.1016/j.landurbplan.2015.06.002

Pătru-Stupariu I., Niţă A., Mustăţea M., Huzui-Stoiculescu A., Fürst C., 2020. Using social network methodological approach to understand Human-Wildlife interactions. Land Use Policy 99: 105009. https://doi.org/10.1016/j.landusepol.2020.105009

Pop I.M., Grădinaru S.R., Popescu V.D., Haase D., Ioja C., 2023. Emergency-line calls as an indicator to assess Human-Wildlife interaction in urban areas. Ecosphere 14(2): 4418. https://doi.org/10.1002/ecs2.4418

Pop I.M., Sallay A., Bereczky L., Chiriac S., 2012. Land use and behavioral patterns of brown bears in the South Eastern Romanian Carpathian Mountains: A case study of relocated and rehabilitated individuals. Procedia Environmental Sciences 14: 111-122. https://doi.org/10.1016/j.proenv.2012.03.011

Pop I.M., Iosif R., Miu I.V., Rozylowicz L., Popescu V.B., 2018. Combining resource selection functions and home-range data to identify habitat conservation priorities for brown bears. Animal Conservation 21(4): 352-36. https://doi.org/10.1111/acv.12399

Popescu V.D., Artelle K.A., Pop I.M., Manolache S., Rozylowicz L., 2016. Assessing biological realism of wildlife population estimates in data-poor systems. Journal for Applied Ecology 53(4): 1248-1259. https://doi.org/10.1111/1365-2664.12660

Popescu V.D., Iosif R., Pop M.I., Chiriac S., Bouroș G., Furnas B.J., 2017. Integrating sign surveys and telemetry data for estimating brown bear (*Ursus arctos*) density in the Romanian Carpathians. Ecology and Evolution 7(18): 7134-7144. https://doi.org/10.1002/ece3.3177

Popescu V.D., Pop M.I., Chiriac S., Rozylowicz L., 2019. Romanian carnivores at a crossroads. Science 364(6445): 1041-1041. https://doi.org/10.1126/science.aax6742

Popescu O.C., Tache A.V., Petrișor AI., 2022. Methodology for Identifying Ecological Corridors: A Spatial Planning Perspective. Land 11(7): 1013. https://doi.org/10.3390/land11071013

Prigioni C., Balestrieri A., Remonti L., Cavada L., 2008. Differential use of food and habitat by sympatric carnivores in the eastern Italian Alps. Italian Journal of Zoology 75(2): 173-184. https://doi.org/10.1080/11250000701885521

Proctor M.F., Kasworm W.F., Annis K.M., MacHutchon A.G., Teisberg J.E., Radandt T.G., Servheen C., 2018. Conservation of threatened Canada-USA trans-border grizzly bears linked to comprehensive vonflict reduction. Human-Wildlife Interactions 12(3): 348-372. https://doi.org/10.26077/yjy6-0m57

Retamosa M.I., Humberg L.A., Beasley J.C., Rhodes Jr O.E., 2008. Modeling wildlife damage to crops in Northern Indiana. Human-Wildlife Interactions 2(2): 225-239. https://doi.org/10.26077/q9z0-tt47

Regia Națională a Pădurilor Romsilva 2020. Arii naturale protejate. Web: https://www.rosilva.ro. Accesed 05.02.2020.

Roellig M., Dorresteijn I., von Wehrden H., Hartel T., Fischer J., 2014. Brown bear activity in traditional wood-pastures in Southern Transylvania, Romania. Ursus 25(1): 43-52. https://doi.org/10.2192/URSUS-D-13-00007.1

Roth A.T., Kleemann J., Spyra M., 2024. Policy-making for peri-urban landscapes as arenas of Human-Wildlife interactions. Urban Ecosystems. https://doi.org/10.1007/s11252-024-01548-8

Rozylowicz L., Chiriac S., Radu S.M., Manolache S., 2010. The habitat selection of a female lynx (*Lynx lynx*) in the northwestern part of the Vrancea Mountains, Romania. North-Western Journal of Zoology 6: 122-127.

Rozylowicz L., Popescu D.V., Pătroescu M., Chișamera G., 2011.The potential of large carnivores as conservation surrogates in the Romanian Carpathians. Biodiversity Conservation 20: 561-579. https://doi.org/10.1007/

s10531-010-9967-x

Ruben I., Pop M.I., Chiriac S., Sandu R.M., Berde L., Rozylowicz L., Popescu V., 2020. Den structure and selection of denning habitat by brown bears in the Romanian Carpathians. Ursus 31e5: 1-13. https://doi.org/10.2192/URSUS-D-18-00010.1

Sandu R.M., 2012. Mic ghid de identificare și interpretare a urmelor, marcajelor și semnelor carnivorelor mari. Focșani. 42 p.

Schulz F., Tais Engel M., Bath A.J., de Oliveira L.R., 2017. Human-Wildlife interactions: the case of big cats in Brazil. In: Campbell M.O., (ed.), Biological Conservation in the 21st Century. Nova Science Publishers Hauppauge, New York: pp 31-56.

Simon T., Bogan E., 2014. Socio-demographic tendencies in the Romanian urban environment included in the Carpathian Convention. International Journal of Academic Research in Environment and Geography 3: 65-75. https://doi.org/10.6007/IJAREG/v3-i1/2209

Sin T., Gazzola A., Chiriac S., Rîșnoveanu G., 2019. Wolf diet and prey selection in the SouthEastern Carpathian Mountains, Romania. PLoS One 14: e0225424. https://doi.org/10.1371/journal.pone.0225424.

Singh N., Sonone W., Dharaiya N., 2018. Sloth bear attacks on humans in Central India: Implications for species conservation. Human-Wildlife Interactions 12(3): 338-347. https://doi.org/10.26077/2mgq-fs29

Sparks Jr J.L., Edward G.J., 2012. An investigation into the use of road drainage structures by wildlife in Maryland, USA. Human-Wildlife Interactions 6(2): 311-326. https://doi.org/10.26077/7exq-t276

Store R., Jokimaki J., 2003. A GIS-based multi-scale approach to habitat suitability modeling. Ecological Modelling 169(1): 1-15. https://doi.org/10.1016/S0304-3800(03)00203-5

Straka M., Paule L., Ionescu O., Štofík J., Adamec M., 2012. Microsatellite diversity and structure of Carpathian brown bears (*Ursus arctos*): consequences of human caused fragmentation. Conservation Genetics 13:153-164. https://doi.org/10.1007/s10592-011-0271-4

Tack J., 2018. Wild Boar (*Sus scrofa*) populations in Europe: a scientific review of population trends and implications for management. European Landowners' Organization, Brussels. 56 p.

Tampakis S., Andrea V., Panagopoulos T., Karanikola P., Gkarmiri R., Georgoula T., 2023. Managing the conflict of Human-Wildlife coexistence: A community-based approach. Land 12(4): 832. https://doi.org/10.3390/land12040832

Takahata C., Nielsen S.E., Takii A., Izumiyama S., 2014. Habitat selection of a large varnivore along Human-Wildlife boundaries in a highly modified landscape. PLoS One 9: e86181. https://doi.org/10.1371/journal.pone.0086181

Thornton C., Quinn M.S. 2009. Coexisting with Cougars: Public perceptions, attitudes, and awareness of vougars on the urban-rural fringe of Calgary, Alberta, Canada. Human-Wildlife Interactions 3(2): 282-295. https://doi.org/10.26077/xvx2-ba39

Thurfjell H., Ball J.P., Åhlén P.A., Kornacher P., Dettki H., Sjöberg K., 2009. Habitat use and spatial patterns of wild boar *Sus scrofa* (L.): Agricultural fields and edges. European Journal for Wildlife Research 55: 517-523. https://doi.org/10.1007/s10344-009-0268-1

Treves A., Karanth K.U., 2003. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17(6): 1491-1499. https://doi.org/10.1111/j.1523-1739.2003.00059.x

Tsunoda H., Raichev E.G., Newman C., Masuda R., Georgiev D.M., Kaneko Y., 2017. Food niche segregation between sympatric golden jackals and red foxes in central Bulgaria. Journal of Zoology 303(1): 64-71. https://doi.org/10.1111/jzo.12464

Vayro J.V., Vandermale E.A., Mason C.W., 2023. 'It's a people problem, not a goat problem.' Mitigating human-mountain goat interactions in a Canadian Provincial Park. Wildlife Research 50(11), 911-926. https://doi.org/10.1071/WR22005

Vărvăruc D., Stoican M., Filip N., 2016. Rolul investițiilor durabile în dezvoltarea turismului inovator din bazinul superior al Văii Prahovei. In: 25 de ani de reformă economică în Republica Moldova: prin inovare şi competitivitate spre progres economic. Departamentul Editorial-Poligrafic al ASEM, Chișinău: pp 213-217.

Voiculescu M., Popescu F., Olaru M., 2012. Patterns of winter tourism wctivity in the Bucegi mountains-the Prahova Valley (the Southern Carpathians). Forum geografic. Studii și cercetări de geografie și protecția mediului 11(2): 182-194. https://doi.org/10.5775/fg.2067-4635.2012.068.d

Wang X.L., Cumming S.G., 2011. Measuring landscape configuration with normalized metrics. Landscape Ecology 26: 723-736. https://doi.org/10.1007/s10980-011-9601-7

Weber J.M., Meia J.S., 1996. Habitat use by the red fox *Vulpes vulpes* in a mountainous area. Ethology Ecology & Evolution 8(3): 223-232. https://doi.org/10.1080/08927014.1996.9522914

Wildlife Conservation Society 2008. QECA Corridor Action Plan 2008-2013. 36 p.

Xia L., Gar-On Yeh A., 2005. Integration of genetic algorithms and GIS for optimal location search. International Journal of Geographical Information Science 19(5): 581-601. https://doi.org/10.1080/13658810500032388

Yumnam B., Jhala Y.V., Qureshi Q., Maldonado J.E., Gopal R., Saini S., Srinivas Y., Fleischer R.C., 2014. Prioritizing tiger vonservation through landscape genetics and habitat linkages. PLoS One 9: e111207. https://doi.org/10.1371/journal.pone.0111207

Zabala - Albizua J., Zuberogoitia I., 2005. Site and landscape features ruling the habitat use and occupancy of the polecat (*Mustela putorius*) in a low - density area: A multiscale approach. European Journal for Wildlife Research 51: 157 - 162. https://doi.org/10.1007/s10344 - 005 - 0094 - z