Acorn availability reduces agricultural damage by ungulates

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Abstract

Human-wildlife conflicts, particularly the damage to agricultural crops caused by ungulates, pose significant ecological and economic challenges. Understanding the role of natural food availability in driving these conflicts is important for developing effective management strategies. We investigated how the pulsed availability of forest tree seeds, i.e., mast seeding, influences the extent of agricultural crop damage in Poland. Using a 19-year national dataset (2001–2020), we analyzed the relationship between oak (*Quercus* spp.) and European beech (*Fagus sylvatica*) seed production, the abundance of wild boar (*Sus scrofa*) and red deer (*Cervus elaphus*), and the area of damaged agricultural crops. We found a negative relationship between oak seed production and the level of crop damage, with estimated damage decreasing by 30% from years of seed failure to years of abundant seed production, supporting the hypothesis that a diet shift occurs in ungulates during years of seed abundance that averts ungulates from damaging the crop. In contrast, beech seed production showed no significant effect on crop damage. Our findings demonstrate that pulsed resource dynamics in forests are an important driver of human-wildlife conflict in adjacent agricultural landscapes.

Introduction

Anthropogenic change has led many taxa to supplement natural foods with agricultural crops, including insects, birds, and especially ungulates (Bereś 2015; Vergin et al. 2025; Jacob et al. 2014; Blount et al. 2021; Montràs-Janer et al. 2019; Brown et al. 2007). In wild boar, a synthesis of 11 studies across eight European countries showed frequent and often large consumption of crops with strong seasonal and geographic variation (Schley and Roper 2003). Crop damage is now a major form of human–wildlife conflict with ecological and socioeconomic costs. Habitat conversion increases animal–human contact, and large-bodied species commonly damage fields, livestock, orchards, and other property, fueling financial losses and negative attitudes (McKee et al. 2021; Hill 2018; Hulme et al. 2020; Distefano 2005; Basak et al. 2023). Because farmland provides accessible, energy-rich food, wildlife turns to anthropogenic sources when natural resources are limited. For example, a 15-year study in Italy reported fewer bear attacks on livestock in years of abundant beech masting but 67% higher attacks in poor mast years (Tattoni et al. 2025). These patterns show how fluctuations in natural food modulate the severity of conflict, highlighting the importance of identifying the ecological drivers of crop damage for better prediction and management. Financial compensation schemes have been introduced in many countries to support those affected (Ravenelle and Nyhus 2017), reaching tens of millions of euros annually (Coordination Rurale 2024; Bleier et al. 2012; Schley, Dufrêne, et al. 2008). Such losses burden farmers, institutions, and taxpayers, and mitigation strategies such as fencing, repellents, regulated hunting (Geisser and Reyer 2004), and supplementary feeding (Calenge et al. 2004) require further investment. Compensation records illustrate the scale of the problem: in 2000/2001 these amounted to nearly 26 million PLN in Poland ($\sim$ 6 mln EUR), rising to 104 million PLN ($\sim$ 24 mln EUR) in 2019/2020 (Główny Urząd Statystyczny 2006; Główny Urząd Statystyczny 2021). Analysis of compensation records from the 2005/2006–2019/2020 hunting seasons showed that, on average, 1.72 thousand PLN was paid per hectare of damaged cropland nationwide (Figure S1 in Supplementary Materials). Pinpointing the environmental drivers of damage is thus important for both ecological understanding, forecasting, and cost-effective management.

Ungulates are major contributors to crop damage due to their large body size, high energy demands, social foraging, and mobility. Wild boar (*Sus scrofa*) and red deer (*Cervus elaphus*) trample fields and consume large amounts of maize, cereals, potatoes, and rapeseed (Massei, Kindberg, et al. 2015; Dzięciołowski 1979; Schley and Roper 2003; Picard et al. 1991). Behaviors such as grubbing alter soil structure (Mohr et al. 2005; Risch et al. 2010), while group foraging increases the spatial extent of damage (Maselli et al. 2014). Yet, agricultural plants supplement rather than replace forest foods. Red deer are herbivorous, shifting seasonally among grasses, shrubs, and conifer needles, and in autumn consume acorns and beechnuts (Gebert and Verheyden 2008; Barrere et al. 2020). Wild boar are omnivorous generalists but depend on energy-dense resources such as acorns, turning to crops or alternative foods when mast is scarce (Massei, Kindberg, et al. 2015). Thus, both species combine forest and agricultural foods, with mast availability shaping their autumn diets (Picard et al. 1991; Schley and Roper 2003).

Masting, the highly interannually variable and synchronized production of large seed crops, is a widespread strategy among European trees, including large-seeded oaks (*Quercus* spp.) and European beech (*Fagus sylvatica*) (Kelly 1994; Bogdziewicz, Kelly, et al. 2024; Szymkowiak et al. 2024). By concentrating reproduction in high-seeding years, trees enhance pollination and reduce seed predation (Zwolak et al. 2022). The resulting pulses of acorns and beechnuts provide critical resources for insects, birds, rodents, and ungulates (Thomas 2008; Myczko et al. 2014; Ruscoe et al. 2005; Schley and Roper 2003). While abundance of invertebrate seed predators is strongly regulated by mast cycles, large-bodied vertebrates such as ungulates can compensate for poor seed years by shifting to alternative foods (Bogdziewicz, Kuijper, et al. 2022; Curran and Leighton 2000). Nevertheless, fluctuations in seed abundance are expected to alter their foraging behavior, space use, and the degree to which they exploit agricultural crops (Zwolak et al. 2022; Pucek et al. 1993; Touzot et al. 2020; Gamelon, Focardi, et al. 2017).

Mast-generated resource pulses also affect ungulate population dynamics. Wild boar depend on at least one energy-rich food source throughout the year, whether mast or crops (Schley and Roper 2003). In high-seeding years, acorn and beechnut availability improves body condition, advances reproduction (Drimaj et al. 2019; Touzot et al. 2020; Cachelou et al. 2022), increases the proportion of breeding females (Gamelon, Touzot, et al. 2021), and leads to larger litters (Touzot et al. 2020), thereby promoting population growth (Massei, Genov, et al. 1996). Access to crops alongside mast can further enhance body size and condition (Merta et al. 2014). In contrast, mortality may increase when mast resources are unavailable, as observed in wild boar from Białowieża Forest, whereas red deer showed no such pattern (Okarma et al. 1995). Thus, while masting has particularly strong demographic effects on wild boar, it also shapes the feeding preferences of both species and modulates their reliance on agricultural foods.

Previous studies show that ungulates preferentially consume mast when available.

In France, Picard et al. (1991) found that during oak high-seeding year, acorns comprised 51% of red deer diet and occurred in 56% of rumen samples, while maize (12%), twigs (9%), and grasses (6%) were secondary. In the preceding poor seed production year, diets shifted toward grasses (20%), maize (12%), leaf stalks (13%), and beechnuts (9%). Long-term data from La Petite Pierre Reserve in northeastern France support these patterns: over 30 years, both red and roe deer increased acorn intake in mast years, with red deer consuming up to 52% of diet compared to 34% in roe deer; in poor years, acorns dropped to 4% and 1% respectively (Barrere et al. 2020). Wild boar show similar responses. A review by Schley and Roper (2003) highlights mast (e.g., seeds of oaks and beech) as a preferred food, with other items taken opportunistically. In the Czech Republic, stomach contents of 182 wild boar collected during a strong oak mast year showed acorns and maize dominating diets, with acorns reaching up to 95% of intake (Mikulka et al. 2018). As acorns declined in winter, maize consumption rose, and acorn presence disappeared. Together, these studies demonstrate that mast abundance strongly shapes ungulate diets. Yet most work has focused on dietary shifts, while the direct link between seed production and the extent of crop damage remains poorly quantified, despite its relevance for anticipating and mitigating human–wildlife conflict.

In this study, we tested whether oak and beech masting influences agricultural damage in Poland by altering ungulate foraging after seedfall. We predicted reduced crop damage in high-seeding years and elevated damage when seed production failed. To examine this, we combined 19 years of national data (2001–2019) on oak and beech seed production, ungulate abundance, and reported crop damage. Our aim was to clarify whether mast seeding modulates conflict intensity and to assess its potential value as an early-warning indicator for targeted, cost-effective management.

Material and Methods

Research area

Poland offers a suitable setting to study interactions between masting and crop damage due to its extensive coverage by both forests and farmland. Oaks (*Quercus robur*, *Q. petraea*) are widespread, while beech (*Fagus sylvatica*) reaches its north-eastern range limit and is locally scarce (Eaton et al. 2016; Durrant et al. 2016). Forest cover increased modestly from 28.4% in 2001 to 29.5% in 2020 (Główny Urząd Statystyczny 2002; Główny Urząd Statystyczny 2020), but connectivity remains low compared to other European countries (Estreguil et al. 2013). Agricultural land dominates the landscape, exceeding 50% of the national area, with sown fields declining from 12.3 to 10.7 million ha over the study period.

Ungulates are widespread across Poland (Borowik et al. 2013), occupying forests, farmland, and even urban areas (Kowalewska 2019). The main ungulate species are wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), roe deer, and fallow deer, with moose and bison present regionally (Michalska et al. 2023; Mysterud et al. 2007). Wild boar populations increased for decades (Massei, Kindberg, et al. 2015) but declined recently due to African Swine Fever (Szymańska and Dziwulaki 2022), whereas deer populations continue to expand across Europe (Burbaitė and Csányi 2010). Poland is divided into hunting districts managed by local associations, which also administer compensation for crop damage. For this study, we used voivodeship-level (N = 16) population estimates reported by the Polish Hunting Association (PZŁ).

Seed production data

We extracted seed production data from MASTREE+, a data set that collects annual reproductive time series data from all over the world and makes these data freely available (Hacket-Pain et al. 2022; Foest et al. 2024). We used data on European beech (*Fagus sylvatica*) and two types of oaks merged under one category (*Quercus robur* and *Quercus petraea*, grouped together as *Quercus* spp.) from 2001 to 2019. This particular data set of seed production from Poland is a part of a long-term monitoring program that began in 1954, covering 17 areas of the Regional Division of State Forests (RDLP) and presenting seed production as the percentage of reproducing trees in a population (Pesendorfer et al. 2020).

To spatially match the seed production data (collected at the level of RDLP) to voivodeships (the level at which crop damage and animal abundance data are collected), we transformed and weighted the seed production data to align with crop damage and animal abundance data, applying the following equation:

$$SP_{v,t} = \sum (SP_{f,t} * wt_f)$$

Seed production in a given voivodship in a given year ($SP_{v,t}$) is calculated as a sum of seed production in each forest division within that year ($SP_{f,t}$), multiplied by the proportion of the forest division overlapping with the voivodship (wt_f).

Seed production exhibited considerable interannual variation across years for both beech (mean coefficient of variation, CV = 1.02, and standard deviation, SD = 23) and oak (CV = 0.66, SD = 17) (Figure 1).

Damaged crops and ungulate count data

We obtained data on reduced crop damage area (hectares) and ungulates populations (number of individuals) spanning 19 hunting seasons from 2000/2001 to 2019/2020 at the voivodeship level, from the Research Station of the Polish Hunting Association (PZŁ) in Czempiń. Their main objective since 1990 has been to monitor game species in Poland. Damaged crop data is a set of annual records of reduced area of damaged agricultural crops for each voivodeship, calculated as the damaged crop area multiplied by the percentage of its destruction. Damaged crop areas and compensation withdrawals for these damages are documented by the divisions of PZŁ and aggregated in annual reports. The number of individuals for each ungulate species is also recorded by hunters across Poland based on year-round observations, and this data is used to create annual hunting plans for the season ahead. It is therefore the estimated number of individuals present in a given area (for our purpose, grouped by voivodeships). We focused on two ungulate species that are widespread and known for damaging crops and consuming beech nuts and acorns: wild boars (*Sus scrofa*) and red deer (*Cervus elaphus*).

Crop damage area showed an increasing trend, rising from under 1000 ha in 2001 to approximately 2500 ha in 2020 and was also characterised by relatively large interannual variation (CV=0.77, SD = 1248, Figure 1). Regarding animal populations, ungulate numbers generally increased over the studied period; however, after 2014, the wild boar population declined sharply due to African Swine Fever (ASF) (Figure 1).

Statistical analysis

We modeled the relationship between crop damage and seed production, taking into account ungulate abundance. We used a generalized linear mixed model with reduced damaged crop area as a response variable, and predictors including two ungulate species abundance (wild boar and red deer, separately) and seed production from two species (beech and oak, separately). All predictors were scaled to enable direct comparisons between them. After visual inspection of the relationships, animal abundance variables were fitted as cubic splines to allow for non-linear relationships. We log-transformed the crop damage records to address skewness in the data (see Figure S2 in Supplementary Materials). The region (voivodeship) was included as a random intercept to account for spatial variations in crop damage and repeated sampling.

We lagged both the ungulate counts and seed production by one year to match the timing of the hunting season, which runs from April 1st to March 31st. The reduced damage area data is referenced to the hunting season (e.g. the 2000/2001 season is recorded as 2001), while the ungulate counts represent the estimated population as of the end of March, which is then used to create the annual hunting plans for the upcoming season (beginning of hunting season e.g. 2000 record is a prediction for 2000/2001 hunting season). Seed production is estimated in a given year, and reflects the food availability for ungulates after the seedfall (within the hunting season, e.g., seeds produced in 2000 are a food source in 2000/2001 hunting season).

To assess the potential impact of African Swine Fever (ASF) on crop damage, we additionally ran models on a shortened time span, using 2015 as a cutoff year (responding to the 2014/2015 hunting season, within which the first known ASF outbreak that happened in Poland). Due to insufficient post-2015 data and the progressive nature of the disease, a classical before–after analysis was not feasible. Therefore, we limited the analysis to the pre-outbreak period and compared it with results from the full dataset. To avoid issues of multicollinearity between the two ungulate species, which were highly correlated ($r = 0.68$ for the full period; $r = 0.91$ before ASF), we fitted separate models for wild boar and red deer.

All analyses were conducted in R (version 4.4.2). We fitted the models via the lme4 package (version 1.1.35.5) (Bates et al. 2015). To generate model-based predictions, we used the ggeffects package (Lüdecke 2018).

Results

In both models, oak seed production was negatively related to agricultural crop damage, while beech seed production showed no significant effect ($p > 0.1$).

In the model including wild boar abundance, oak masting significantly reduced crop damage ($\beta = -0.07$, $SE = 0.02$, $p < 0.01$), while wild boar abundance had a strong positive effect ($\beta_1 = 0.647$, $SE = 0.153$, $p < 0.001$, $\beta_2 = 1.820$, $SE = 0.234$, $p < 0.001$, $\beta_3 = 1.226$, $SE = 0.226$, $p < 0.001$). Assuming average conditions, predicted damage decreased from $\sim$ 1828 ha at low oak seed production to $\sim$ 1295 ha at maximum acorn production (Figure 2 A.), representing a $\sim$ 29% reduction in actual area damaged. In contrast, wild boar abundance had a strong positive effect, where predicted crop damage increased from $\sim$ 452 ha at low abundance to $\sim$ 1925 ha (Figure 2 B.) at high abundance, corresponding to more than a threefold increase.

In the red deer model, oak seed production again had a negative effect ($\beta = -0.10$, $SE = 0.02$, $p < 0.001$), where assuming average conditions predicted crop damage decreased from $\sim$ 2977 ha at low oak seed production to $\sim$ 1828 ha, which accounted for a $\sim$ 38% reduction. Red deer abundance was a strong positive predictor of crop damage ($\beta_1 = 2.133$, $SE = 0.133$, $p < 0.001$, $\beta_2 = 4.483$, $SE = 0.206$, $p < 0.001$, $\beta_3 = 2.553$, $SE = 0.168$, $p < 0.001$). Predicted damage increased from $\sim$ 224 ha at low abundance to $\sim$ 6135 ha at highest values - a more than twentyfold rise (Figure 2 C.).

Across both model configurations, oak masting reduced crop damage, while ungulate abundance remained the dominant positive driver. The negative effects of oak masting on crop damage persisted when analyzing only the period before the ASF outbreak (Table S1 in Supplementary Materials).

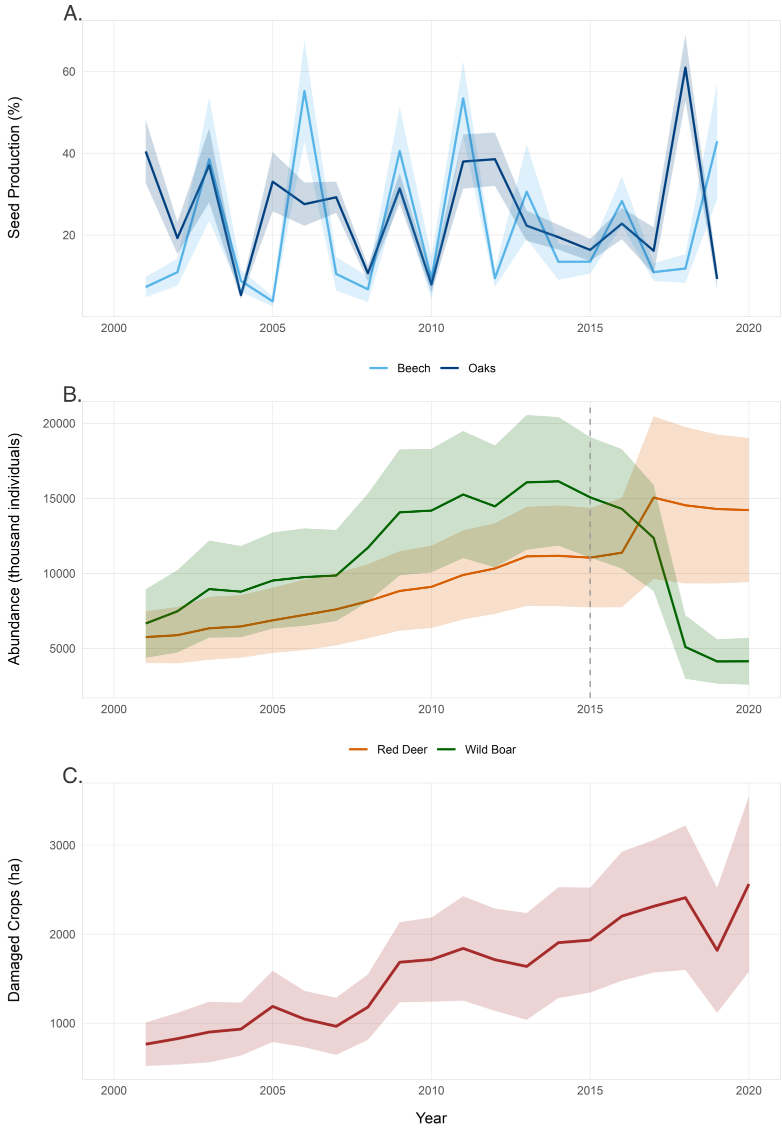

Figure 1: Temporal trends in seed production, ungulate populations and crop damage across all study regions. A) Annual seed production of beech and oaks over time. B) Annual crop damage area across all regions. C) Population trends of red deer and wild boar across all districts. Solid lines represent means and shaded areas indicate one standard deviation around the mean. The vertical dashed line indicates the African Swine Fever (ASF) outbreak (2015).

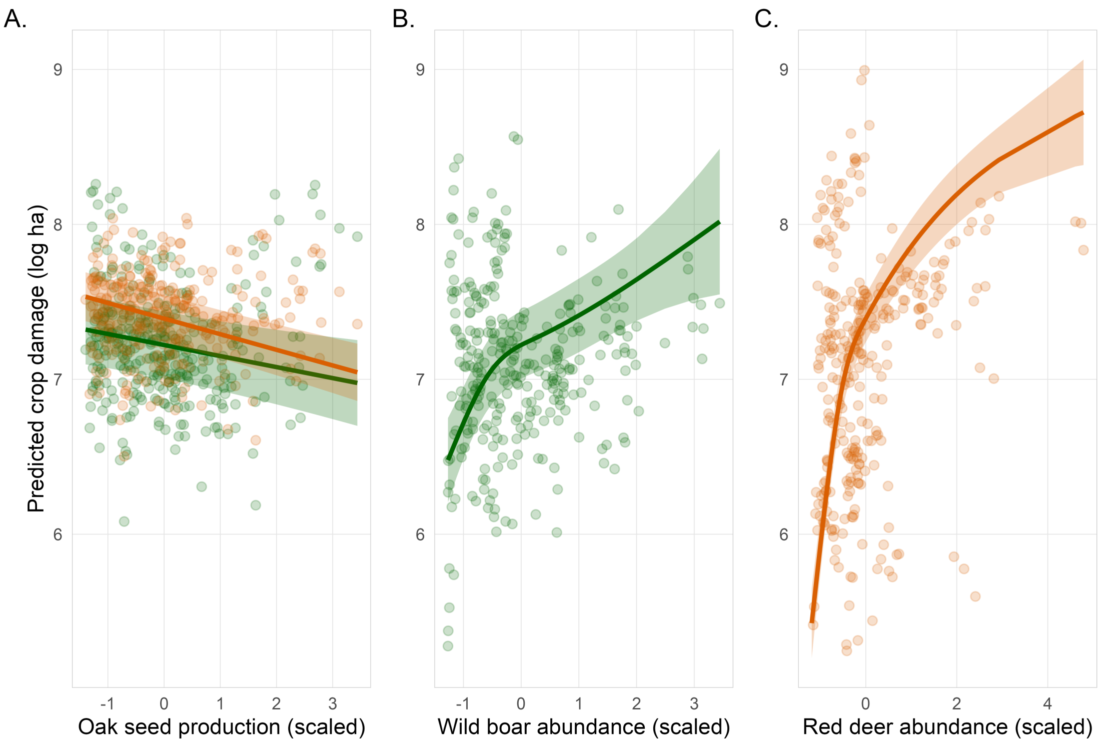

Figure 2: Estimated relationships between crop damage and ecological predictors across the full study period. Panels show estimated crop damage (ha) in relation to (A) oak seed production, (B) wild boar abundance, and (C) red deer abundance. Beech seed production was not a significant predictor of crop damage (Table S1). Lines represent estimated mean values with 95% confidence intervals (shaded areas), and points show partial residuals. Colors show predictions derived from separate models (green - that included wild boar abundance as a predictor; orange - red deer abundance). Predictors were scaled before entering the model. Estimates were derived from linear mixed models with voivodeship included as a random intercept. The conditional R^2 of the model that included wild boar abundance and seed production of both species as predictors was 0.65, while the marginal R^2 was 0.25. The conditional R^2 of the model that included red deer abundance and seed production of both species as predictors was 0.90, while the marginal R^2 was 0.76.

Discussion

Our results show that interannual variation in natural food, specifically oak masting, modulates the intensity of human–wildlife conflict. We found a negative relationship between acorn availability and the area of damaged crops, with predicted damage decreasing by over 30% between years of lowest and highest oak seed production. This indicates that high-seeding years buffer conflict by reducing the need for ungulates to forage in fields. The pattern suggests that energy-rich acorns act as a substitute resource, lowering reliance on agricultural foods when abundant, while poor mast years intensify pressure on farmland. By linking dietary flexibility of ungulates to a direct, management-relevant outcome, these results extend earlier work that focused mainly on diet composition. Practically, acorn availability emerges as a useful indicator of conflict risk: integrating mast seeding with regional factors such as forest composition, proximity of farmland to oak stands, and animal movements across administrative borders could support more targeted deployment of mitigation strategies. The fact that we detected this effect using broad-scale, non-targeted data suggests that in oak-rich landscapes with strong fruiting, the local strength of this relationship may be even greater.

In contrast to oak, beech seed production did not show a significant influence on crop damage in our analyses. This could due to the lower nutritional value and smaller size of beechnuts compared to acorns (Rivero et al. 2019). Even during mast years, beechnuts may not constitute a sufficient resource to become a primary food source for large ungulates. From a management perspective, our results imply that monitoring oak flowering intensity can be a valuable forecasting tool, whereas tracking beech flowering may be less critical given its negligible impact. Indeed, reports from other countries indicate that beech masting impacted ungulate population dynamics to a lesser extent than oak masting (Gamelon, Focardi, et al. 2017). It is worth noting, though, that the positive correlation (r=0.28) we observed between oak and beech seed production during our study might have partially masked any potential, separate effect of the latter species.

Our analysis indicates that the abundance of key game species had a substantial impact on the extent of crop damage, and it has been shown in previous studies in Poland that agricultural crops are a significant component of their diet (Gebert and Verheyden 2008; Kniżewska and Rekiel 2015). It is important to acknowledge, however, that our analysis of animal abundance, based on hunter observations, is subject to methodological limitations, as observer expertise and financial incentives can introduce biases into population estimates (Kamieniarz et al. 2023). These limitations prevented us from assessing a direct numerical response of ungulates to seed production, but it remains evident that animal abundance is a critical factor intensifying human-wildlife conflicts.

We observed that recent (since 2015), drastic shifts in the ungulate community structure, i.e., rising deer numbers and the decline of wild boar due to African Swine Fever (ASF) did not erase the overall significant influence of oak seed production. It is, however, important to note that the wild boar population decline was driven by several interconnected factors: direct mortality from the disease, extensive sanitary culling, and intensified hunting pressure related to management policies, with spatially variable intensity across regions The subsequent spatiotemporal spread of the epidemic (Wojewódzki Inspektorat Weterynarii 2019) likely had profound and regionally varied effects. However, the limited number of observations in the post-ASF period prevented us from conducting a formal statistical comparison between the two periods.

The species analyzed are game animals, and hunting remains the primary population management tool in Europe. However, high hunting pressure can induce fear, altering animal behavior—potentially creating ”refugee effects” (Amici et al. 2012) where animals avoid certain areas—and influencing their use of agricultural landscapes (Sütő et al. 2023). Hunting pressure can also drive evolutionary consequences, such as earlier reproduction in wild boars (Gamelon, Besnard, et al. 2011). Furthermore, hunting pressure might obscure the effects of seed production on population dynamics at local scales, for example, by maintaining animal populations at low levels. Management recommendations should therefore integrate these environmental factors to better forecast potential crop losses. While the ongoing recovery of large predators like wolves in Poland (Chapron et al. 2014; Di Bernardi et al. 2025) could theoretically help regulate ungulate populations, habitat fragmentation and other anthropogenic influences may limit their effectiveness in keeping ungulate numbers under control (van Beeck Calkoen et al. 2023). Therefore, it could be beneficial to align hunting strategies with oak seed production, as masting can influence not only the extent of wildlife impact on agriculture, but also population dynamics in the subsequent months. In conclusion, our findings demonstrate that oak seed production plays a significant role in shaping crop damage by altering ungulate foraging behavior. This interaction occurs within a complex socio-ecological context influenced by climate, habitat structure, and human management, suggesting that integrating regional seed production forecasts with landscape composition data and adaptive wildlife management practices may provide substantial benefits for mitigating human-wildlife conflicts.

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Supplementary Materials

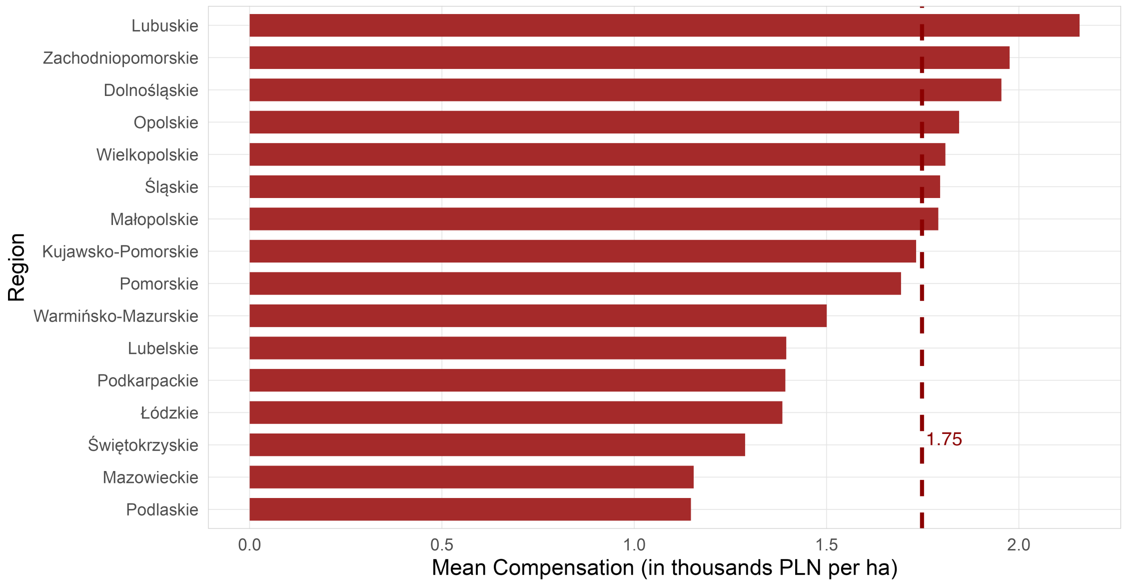

Figure S1: Mean compensations per 1 hectare of damaged crop area for all regions in hunting seasons 2005/2006–2019/2020. The red line represents the calculated mean for the whole of Poland.

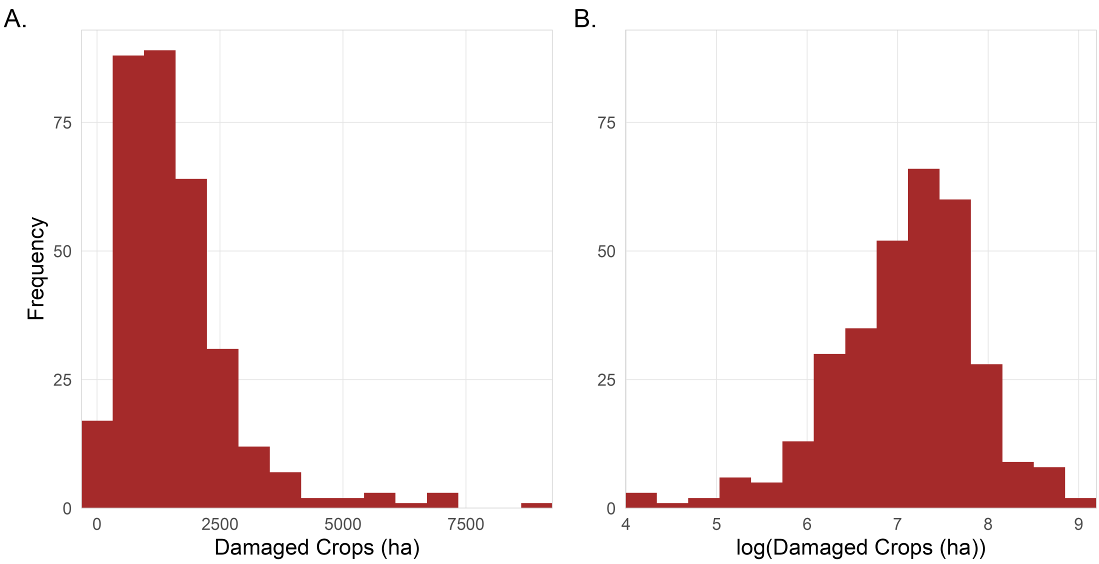

Figure S2: Distribution of damaged crop area (ha) before (A.) and after (B.) log-transformation.

Model	Predictors	Estimates	Std. E.	df	p-value
Wild boar full period	Beech seed production	0.03	0.02	281.73	0.24
	Oak seed production	-0.07	0.02	283.66	0.003
	Wild boar abundance$_1$	0.65	0.15	297.81	>0.001
	Wild boar abundance$_2$	1.82	0.23	297.87	>0.001
	Wild boar abundance$_3$	1.23	0.23	296.27	>0.001
Red deer full period	Beech seed production	0.01	0.02	283.76	0.64
	Oak seed production	-0.10	0.02	284.32	>0.001
	Red deer abundance$_1$	2.13	0.13	282.94	>0.001
	Red deer abundance$_2$	4.48	0.21	290.99	>0.001
	Red deer abundance$_3$	2.55	0.17	297.77	>0.001
Wild boar before ASF	Beech seed production	-0.03	0.01	205.95	0.02
	Oak seed production	-0.05	0.01	205.29	>0.001
	Wild boar abundance$_1$	1.60	0.09	217.15	>0.001
	Wild boar abundance$_2$	4.33	0.15	216.79	>0.001
	Wild boar abundance$_3$	2.48	0.12	217.04	>0.001
Red deer before ASF	Beech seed production	0.01	0.02	204.54	0.72
	Oak seed production	-0.09	0.02	204.23	>0.001
	Red deer abundance$_1$	1.95	0.15	207.39	>0.001
	Red deer abundance$_2$	4.56	0.27	204.79	>0.001
	Red deer abundance$_3$	2.71	0.20	213.41	>0.001

Table S1: Linear Mixed-Effects Regression fixed effects for seed production and ungulate abundance for full period and before the ASF outbreak. Animal abundance variables were fitted as cubic splines to allow for non-linear relationships.

Bibliography

Amici, A., F. Serrani, C. M. Rossi, and R. Primi (2012). “Increase in crop damage caused by wild boar (*Sus scrofa* L.): the “refuge effect””. In: *Agronomy for Sustainable Development* 32.3, pp. 683–692. DOI: 10.1007/s13593-011-0057-6.

Barrere, J., V. Boulanger, C. Collet, E. Walker, V. Siat, et al. (2020). “How does oak mast seeding affect the feeding behavior of sympatric red and roe deer?” In: *Basic and Applied Ecology* 47, pp. 83–94. DOI: 10.1016/j.baae.2020.04.006.

Basak, S. M., E. Rostovskaya, J. Birks, and I. A. Wierzbowska (2023). “Perceptions and attitudes to understand human–wildlife conflict in an urban landscape – A systematic review”. In: *Ecological Indicators* 151, p. 110319. DOI: 10.1016/j.ecolind.2023.110319.

Bates, D., M. Mächler, B. Bolker, and S. Walker (2015). “Fitting Linear Mixed-Effects Models Using lme4”. In: *Journal of Statistical Software* 67.1, pp. 1–48. DOI: 10.18637/jss.v067.i01.

Bereś, P. (2015). “The occurrence and harmfulness of *Oscinella frit* L. (Diptera: Chloropidae) to maize cultivars cultivated for grain in south-eastern Poland”. In: *Acta Scientiarum Polonorum. Agricultura* 14, pp. 15–24.

Bleier, N., R. Lehoczki, D. Újváry, L. Szemethy, and S. Csányi (2012). “Relationships between wild ungulates density and crop damage in Hungary”. In: *Acta Theriologica* 57.4, pp. 351–359. DOI: 10.1007/s13364-012-0082-0.

Blount, J. D., J. J. Horns, K. D. Kittelberger, M. H. C. Neate-Clegg, and Ç. H. Şekercioğlu (2021). “Avian Use of Agricultural Areas as Migration Stopover Sites: A Review of Crop Management Practices and Ecological Correlates”. In: *Frontiers in Ecology and Evolution* 9. DOI: 10.3389/fevo.2021.650641.

Bogdziewicz, M., D. Kelly, D. Ascoli, T. Caignard, F. Chianucci, E. E. Crone, E. Fleurot, J.-J. Foest, G. Gratzer, T. Hagiwara, Q. Han, V. Journé, L. Keurinck, K. Kondrat, R. McClory, J. M. LaMontagne, I. A. Mundo, A. Nussbaumer, I. Oberklammer, M. Ohno, I. S. Pearse, M. B. Pesendorfer, G. Resente, A. Satake, M. Shibata, R. S. Snell, J. Szymkowiak, L. Touzot, R. Zwolak, M. Zywiec, and A. J. Hacket-Pain (2024). “Evolutionary ecology of masting: mechanisms, models, and climate change”. In: *Trends in Ecology & Evolution* 39.9, pp. 851–862. DOI: 10.1016/j.tree.2024.05.006.

Bogdziewicz, M., Dries Kuijper, Rafał Zwolak, Mariusz Churski, Bogumiła Jędrzejewska, Elżbieta Wysocka-Fijorek, Aleksandra Gazda, Szymon Miścicki, and Tomasz Podgórski (2022). "Emerging infectious disease triggered a trophic cascade and enhanced recruitment of a masting tree". In: *Proceedings. Biological Sciences* 289.1970, p. 20212636. DOI: 10.1098/rspb.2021.2636.

Borowik, T., T. Cornulier, and B. Jędrzejewska (2013). "Environmental factors shaping ungulate abundances in Poland". In: *Acta Theriologica* 58.3, pp. 403–413. DOI: 10.1007/s13364-013-0153-x.

Brown, P. R., N. I. Huth, P. B. Banks, and G. R. Singleton (2007). "Relationship between abundance of rodents and damage to agricultural crops". In: *Agriculture, Ecosystems & Environment* 120.2, pp. 405–415. DOI: 10.1016/j.agee.2006.10.016.

Burbaitė, L. and S. Csányi (2010). "Red deer population and harvest changes in Europe". In: *Acta Zoologica Lituanica* 20, pp. 179–188. DOI: 10.2478/v10043-010-0038-z.

Cachelou, J., C. Saint-Andrieux, E. Baubet, E. Nivois, E. Richard, J.-M. Gaillard, and M. Gamelon (2022). "Does mast seeding shape mating time in wild boar? A comparative study". In: *Biology Letters* 18.7, p. 20220213. DOI: 10.1098/rsbl.2022.0213.

Calenge, C., D. Maillard, P. Fournier, and C. Fouque (2004). "Efficiency of spreading maize in the garrigues to reduce wild boar (*Sus scrofa*) damage to Mediterranean vineyards". In: *European Journal of Wildlife Research* 50.4, pp. 198–206. DOI: 10.1007/s10344-004-0047-y.

Chapron, G., P. Kaczensky, J. D. C. Linnell, M. Von Arx, D. Huber, H. Andrén, J. V. López-Bao, M. Adamec, F. Álvares, O. Anders, L. Balčiauskas, V. Balys, P. Bedő, F. Bego, J. C. Blanco, U. Breitenmoser, H. Brøseth, L. Bufka, R. Bunikyte, P. Ciucci, A. Dutsov, T. Engleder, C. Fuxjäger, C. Groff, K. Holmala, B. Hoxha, Y. Iliopoulos, O. Ionescu, J. Jeremić, K. Jerina, G. Kluth, F. Knauer, I. Kojola, I. Kos, M. Krofel, J. Kubala, S. Kunovac, J. Kusak, M. Kutal, O. Liberg, A. Majić, P. Männil, R. Manz, E. Marboutin, F. Marucco, D. Melovski, K. Mersini, Y. Mertzanis, R. W. Mysłajek, S. Nowak, J. Odden, J. Ozolins, G. Palomero, M. Paunović, J. Persson, H. Potočnik, P.-Y. Quenette, G. Rauer, I. Reinhardt, R. Rigg, A. Ryser, V. Salvatori, T. Skrbinšek, A. Stojanov, J. E. Swenson, L. Szemethy, A. Trajçe, E. Tsingarska-Sedefcheva, M. Váňa, R. Veeroja, P. Wabakken, M. Wölfl, S. Wölfl, F. Zimmermann, D. Zlatanova, and L. Boitani (2014). "Recovery of large carnivores in Europe's modern human-dominated landscapes". In: *Science* 346.6216, pp. 1517–1519.

Coordination Rurale (2024). *Bilan 2023 des dégâts de gibier*. Accessed in 2024.

Curran, Lisa and Mark Leighton (Jan. 2000). "Curran LM, Leighton M. 2000. Vertebrate responses to spatio-temporal variation in seed production by mast-fruiting Bornean Dipterocarpaceae. Ecol Monogr". In: *Ecological Monographs* 70.

Di Bernardi, C., G. Chapron, P. Kaczensky, F. Álvares, H. Andrén, et al. (2025). "Continuing recovery of wolves in Europe". In: *PLOS Sustainability and Transformation* 4.2, e0000158. DOI: 10.1371/journal.pstr.0000158.

Distefano, E. (2005). *Human-Wildlife Conflict Worldwide: A Collection of Case Studies, Analysis of Management Strategies and Good Practices*. SARD Initiative Report. Rome: FAO.

Drimaj, J., J. Kamler, M. Hošek, J. Zeman, R. Plhal, O. Mikulka, and T. Kudláček (2019). "Reproductive characteristics of wild boar males (*Sus scrofa*) under different environmental conditions". In: *Acta Veterinaria Brno*. DOI: 10.2754/avb201988040401.

Durrant, T. H., D. de Rigo, and G. Caudullo (2016). "*Fagus sylvatica* and other beeches in Europe: distribution, habitat, usage and threats". In: *European Atlas of Forest Tree Species*. Ed. by J. San-Miguel-Ayanz, D. de Rigo, G. Caudullo, T. H. Durrant, and A. Mauri. Luxembourg: Publications Office of the European Union.

Dzięciołowski, R. (1979). "Structure and Spatial Organization of Deer Populations". In: *Acta Theriologica* 24.1, pp. 3–21.

Eaton, E., G. Caudullo, S. Oliveira, and D. de Rigo (2016). "*Quercus robur* and *Quercus petraea* in Europe: distribution, habitat, usage and threats". In: *European Atlas of Forest Tree Species*. Ed. by J. San-Miguel-Ayanz, D. de Rigo, G. Caudullo, T. H. Durrant, and A. Mauri. Luxembourg: Publications Office of the European Union.

Estreguil, C., G. Caudullo, D. De Rigo, and J. San Miguel (2013). *Forest landscape in Europe: pattern, fragmentation and connectivity*. Publications Office of the European Union. DOI: 10.2788/77842.

Foest, J. J., Michał Bogdziewicz, Mario B. Pesendorfer, Davide Ascoli, Andrea Cutini, Annika Nussbaumer, Arne Verstraeten, Burkhard Beudert, Francesco Chianucci, Francesco Mezzavilla, Georg Gratzer, Georges Kunstler, Henning Meesenburg, Michael Wagner, Martina Mund, Nathalie Cools, Stanislav Vacek, Wolfgang Schmidt, Zdeněk Vacek, and Alexander Hacket-Pain (2024). "Widespread breakdown in masting in European beech due to rising summer temperatures". In: *Global Change Biology* 30, e17307. DOI: 10.1111/gcb.17307.

Gamelon, M., A. Besnard, J.-M. Gaillard, S. Servanty, E. Baubet, S. Brandt, and O. Gimenez (2011). "High hunting pressure selects for earlier birth date: wild boar as a case study". In: *Evolution* 65.11, pp. 3100–3112. DOI: 10.1111/j.1558-5646.2011.01366.x.

Gamelon, M., S. Focardi, E. Baubet, S. Brandt, B. Franzetti, F. Ronchi, S. Venner, B.-E. Sæther, and J.-M. Gaillard (2017). "Reproductive allocation in pulsed-resource environments: a comparative study in two populations of wild boar". In: *Oecologia* 183.4, pp. 1065–1076. DOI: 10.1007/s00442-017-3821-8.

Gamelon, M., L. Touzot, É. Baubet, J. Cachelou, S. Focardi, B. Franzetti, É. Nivois, L. Veylit, and B.-E. Sæther (2021). "Effects of pulsed resources on the dynamics of seed consumer populations: a comparative demographic study in wild boar". In: *Ecosphere* 12.5, e03395. DOI: 10.1002/ecs2.3395.

Gebert, C. and H. Verheyden (2008). "Variations of diet composition of Red Deer (*Cervus elaphus* L.) in Europe". In: *Mammal Review* 31, pp. 189–201. DOI: 10.1111/j.1365-2907.2001.00090.x.

Geisser, H. and H.-U. Reyer (2004). "Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boars". In: *Journal of Wildlife Management* 68.4, pp. 939–946. DOI: 10.2193/0022-541X(2004)068[0939:EOHFAF]2.0.CO;2.

Główny Urząd Statystyczny (2002). *Rocznik Statystyczny Leśnictwa 2002*. Warszawa: Główny Urząd Statystyczny.

– (2006). *Leśnictwo 2005*. Warszawa: Zakład Wydawnictw Statystycznych.

– (2020). *Rocznik Statystyczny Leśnictwa 2020*. Warszawa: Główny Urząd Statystyczny.

– (2021). *Rocznik Statystyczny Leśnictwa 2021 / Statistical Yearbook of Forestry 2021*. Warszawa: Zakład Wydawnictw Statystycznych.

Hacket-Pain, A., J. J. Foest, I. S. Pearse, J. M. LaMontagne, W. D. Koenig, G. Vacchiano, M. Bogdziewicz, T. Caignard, P. Celebias, J. van Dormolen, M. Fernández-Martínez, J. V. Moris, C. Palaghianu, M. Pesendorfer, A. Satake, E. Schermer, A. J. Tanentzap, P. A. Thomas, D. Vecchio, A. P. Wion, T. Wohlgemuth, T. Xue, K. Abernethy, M.-C. Aravena Acuña, M. D. Barrera, J. H. Barton, S. Boutin, E. R. Bush, S. Donoso Calderón, F. S. Carevic, C. V. de Castilho, J. M. Cellini, C. A. Chapman, H. Chapman, F. Chianucci, P. da Costa, L. Croisé, A. Cutini, B. Dantzer, R. J. DeRose, J.-T. Dikangadissi, E. Dimoto, F. L. da Fonseca, L. Gallo, G. Gratzer, D. F. Greene, M. A. Hadad, A. H. Herrera, K. J. Jeffery, J. F. Johnstone, U. Kalbitzer, W. Kantorowicz, C. A. Klimas, J. G. A. Lageard, J. Lane, K. Lapin, M. Ledwoń, A. C. Leeper, M. V. Lencinas, A. C. Lira-Guedes, M. C. Lordon, P. Marchelli, S. Marino, H. Schmidt Van Marle, A. G. McAdam, L. R. W. Momont, M. Nicolas, L. H. de Oliveira Wadt, P. Panahi, G. Martínez Pastur, T. Patterson, P. L. Peri, Ł. Piechnik, M. Pourhashemi, C. Espinoza Quezada, F. A. Roig, K. Peña Rojas, Y. M. Rosas, S. Schueler, B. Seget, R. Soler, M. A. Steele, M. Toro-Manríquez, C. E. G. Tutin, T. Ukizintambara, L. White, B. Yadok, J. L. Willis, A. Zolles, M. Żywiec, and D. Ascoli (2022). "MASTREE+: Time-series of plant reproductive effort from six continents". In: *Global Change Biology* 28.9, pp. 3066–3082. DOI: 10.1111/gcb.16130.

Hill, C. M. (2018). "Crop Foraging, Crop Losses, and Crop Raiding". In: *Annual Review of Anthropology* 47, pp. 377–394. DOI: 10.1146/annurev-anthro-102317-050022.

Hulme, Mark F., Fiona J. Sanderson, and Juliet A. Vickery (2020). "Impacts of wildlife on tropical agro-forestry crops, and the implications for international conservation initiatives". In: *International Journal of Pest Management* 66.1, pp. 1–10. DOI: 10.1080/09670874.2018.1538545.

Jacob, J., P. Manson, R. Barfknecht, and T. Fredricks (2014). "Common vole (*Microtus arvalis*) ecology and management: implications for risk assessment of plant protection products". In: *Pest Management Science* 70.6, pp. 869–878. DOI: 10.1002/ps.3695.

Kamieniarz, R., M. Jakubowski, M. Dyderski, G. Górecki, P. Nasiadka, H. Okarma, M. Pudełko, J. Skubis, A. Tomek, M. Wajdzik, P. Mederski, P. Skorupski, and M. Skorupski (2023). "Application of the tyraliera counting method to the large-scale inventory of red deer *Cervus elaphus* in the northern part of Western Pomerania, Poland". In: *Annals of Forest Research* 66, pp. 33–44. DOI: 10.15287/afr.2023.2234.

Kelly, D. (1994). "The evolutionary ecology of mast seeding". In: *Trends in Ecology & Evolution* 9.12, pp. 465–470. DOI: 10.1016/0169-5347(94)90310-7.

Kniżewska, W. and A. Rekiel (2015). "Evaluation of variation in game damage caused by the European wild boar (*Sus scrofa* L.) in two forested hunting regions during the 2005/2006 and 2012/2013 seasons". In: *Scientific Annals of Polish Society of Animal Production* 11.3, pp. 81–93.

Kowalewska, A. (2019). "Feral Urban Wild Boars: Managing Spaces of Conflict with Care and Attention". In: *Przegląd Kulturoznawczy*, pp. 524–538. DOI: 10.4467/20843860PK.19.027.11923.

Lüdecke, D. (2018). "ggeffects: Tidy Data Frames of Marginal Effects from Regression Models". In: *Journal of Open Source Software* 3.26, p. 772. DOI: 10.21105/joss.00772.

Maselli, V., D. Rippa, G. Russo, R. Ligrone, O. Soppelsa, B. D'Aniello, P. Raia, and D. Fulgione (2014). "Wild boars' social structure in the Mediterranean habitat". In: *Italian Journal of Zoology* 81. DOI: 10.1080/11250003.2014.953220.

Massei, G., P. V. Genov, and B. W. Staines (1996). "Diet, food availability and reproduction of wild boar in a Mediterranean coastal area". In: *Acta Theriologica* 41.3, pp. 307–320. DOI: 10.4098/AT.arch.96-30.

Massei, G., J. Kindberg, A. Licoppe, D. Gačić, N. Šprem, J. Kamler, E. Baubet, U. Hohmann, A. Monaco, J. Ozoliņš, S. Cellina, T. Podgórski, C. Fonseca, N. Markov, B. Pokorny, C. Rosell, and A. Náhlik (2015). "Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe". In: *Pest Management Science* 71.4, pp. 492–500. DOI: 10.1002/ps.3965.

McKee, S. C., S. A. Shwiff, and A. M. Anderson (2021). "Estimation of wildlife damage from federal crop insurance data". In: *Pest Management Science* 77.1, pp. 406–416. DOI: 10.1002/ps.6031.

Merta, D., P. Mocała, M. Pomykacz, and W. Frackowiak (2014). "Autumn-winter diet and fat reserves of wild boars (*Sus scrofa*) inhabiting forest and forest-farmland environment in south-western Poland". In: *Folia Zoologica* 63.2, pp. 100–107. DOI: 10.25225/fozo.v63.i2.a7.2014.

Michalska, K., M. Wójcik, K. Tajchman, and J. Batkowska (2023). "Charakterystyka populacji łosia w środkowo-wschodniej Polsce". In: *Wiadomości Zootechniczne* 19.4, pp. 69–79. DOI: 10.5604/01.3001.0054.3016.

Mikulka, O., J. Zeman, J. Drimaj, R. Plhal, Z. Adamec, J. Kamler, and M. Heroldová (2018). "The importance of natural food in wild boar (*Sus scrofa*) diet during autumn and winter". In: *Folia Zoologica* 67.3–4, pp. 165–172. DOI: 10.25225/fozo.v67.i3-4.a3.2018.

Mohr, D., L. W. Cohnstaedt, and W. Topp (2005). "Wild boar and red deer affect soil nutrients and soil biota in steep oak stands of the Eifel". In: *Soil Biology and Biochemistry* 37.4, pp. 693–700. DOI: 10.1016/j.soilbio.2004.10.002.

Montràs-Janer, T., J. Knape, L. Nilsson, I. Tombre, T. Pärt, and J. Månsson (2019). "Relating national levels of crop damage to the abundance of large grazing birds: Implications for management". In: *Journal of Applied Ecology* 56.10, pp. 2286–2297. DOI: 10.1111/1365-2664.13457.

Myczko, Ł., Ł. Dylewski, P. Zduniak, T. H. Sparks, and P. Tryjanowski (2014). "Predation and dispersal of acorns by European Jay (*Garrulus glandarius*) differs between a native (Pedunculate Oak *Quercus robur*) and an introduced oak species (Northern Red Oak *Quercus rubra*) in Europe". In: *Forest Ecology and Management* 331, pp. 35–39. DOI: 10.1016/j.foreco.2014.08.017.

Mysterud, A., K. Bartoń, B. Jędrzejewska, Z. A. Krasiński, M. Niedziałkowska, J. Kamler, N. G. Yoccoz, and N. C. Stenseth (2007). "Population ecology and conservation of endangered megafauna: The case of European bison in Białowieża Primeval Forest, Poland". In: *Animal Conservation* 10, pp. 77–87. DOI: 10.1111/j.1469-1795.2006.00075.x.

Okarma, H., B. Jędrzejewska, W. Jędrzejewski, Z. A. Krasiński, and L. Miłkowski (1995). "The roles of predation, snow cover, acorn crop, and man-related factors on ungulate mortality in Białowieża Primeval Forest, Poland". In: *Acta Theriologica* 40.2, pp. 197–217. DOI: 10.4098/AT.arch.95-20.

Pesendorfer, M. B., M. Bogdziewicz, J. Szymkowiak, Z. Borowski, W. Kantorowicz, J. M. Espelta, and M. Fernández-Martínez (2020). "Investigating the relationship between climate, stand age, and temporal trends in masting behavior of European forest trees". In: *Global Change Biology* 26.3, pp. 1654–1667. DOI: 10.1111/gcb.14945.

Picard, J. F., P. Oleffe, and B. Boisaubert (1991). “Influence of oak mast on feeding behaviour of red deer (*Cervus elaphus* L)”. In: *Annals of Forest Science* 48.5, pp. 547–559. DOI: 10.1051/forest:19910505.

Pucek, Z., W. Jędrzejewski, B. Jędrzejewska, and M. Pucek (1993). “Rodent population dynamics in a primeval deciduous forest (Białowieża National Park) in relation to weather, seed crop, and predation”. In: *Acta Theriologica* 38, pp. 199–232.

Ravenelle, J. and P. J. Nyhus (2017). “Global patterns and trends in human–wildlife conflict compensation”. In: *Conservation Biology* 31, pp. 1247–1256. DOI: 10.1111/cobi.12948.

Risch, A. C., S. Wirthner, M. D. Busse, D. S. Page-Dumroese, and M. Schütz (2010). “Grubbing by wild boars (*Sus scrofa* L.) and its impact on hardwood forest soil carbon dioxide emissions in Switzerland”. In: *Oecologia* 164.3, pp. 773–784. DOI: 10.1007/s00442-010-1665-6.

Rivero, M. J., V. Rodríguez-Estévez, S. Pietrosemoli, C. Carballo, A. Cooke, and A. Kongsted (2019). “Forage Consumption and Its Effects on the Performance of Growing Swine—Discussed in Relation to European Wild Boar (*Sus scrofa* L.) in Semi-Extensive Systems: A Review”. In: *Animals* 9, p. 457. DOI: 10.3390/ani9070457.

Ruscoe, W. A., J. S. Elkinton, D. Choquenot, and R. B. Allen (2005). “Predation of beech seed by mice: effects of numerical and functional responses”. In: *Journal of Animal Ecology* 74.6, pp. 1005–1019. DOI: 10.1111/j.1365-2656.2005.00998.x.

Schley, L., M. Dufrêne, A. Krier, and A. C. Frantz (2008). “Patterns of crop damage by wild boar (*Sus scrofa*) in Luxembourg over a 10-year period”. In: *European Journal of Wildlife Research* 54.4, pp. 589–599. DOI: 10.1007/s10344-008-0183-x.

Schley, L. and T. J. Roper (2003). “Diet of wild boar *Sus scrofa* in Western Europe, with particular reference to consumption of agricultural crops”. In: *Mammal Review* 33.1, pp. 43–56. DOI: 10.1046/j.1365-2907.2003.00010.x.

Sütő, D., S. Siffer, J. Farkas, and K. Katona (2023). “Predictability of the spatiotemporal pattern of wild boar (*Sus scrofa*) rooting influenced by acorn availability”. In: *Forests* 14.12, p. 2319. DOI: 10.3390/f14122319.

Szymańska, E. and M. Dziwulaki (2022). “Development of African Swine Fever in Poland”. In: *Agriculture* 12, p. 119. DOI: 10.3390/agriculture12010119.

Szymkowiak, J., J. Foest, A. Hacket-Pain, V. Journé, D. Ascoli, and M. Bogdziewicz (2024). *Tail-dependence of masting synchrony results in continent-wide seed scarcity.* Preprint. DOI: 10.32942/X2ZG85.

Tattoni, C., A. Corradini, F. Chianucci, F. Bisi, M. Ciolli, N. Bragalanti, C. Groff, A. Martinoli, and D. G. Preatoni (2025). “Behaviour of brown bears under fluctuating resource availability”. In: *Authorea*. DOI: 10.22541/au.173720386.60139244/v1.

Thomas, Peter (2008). “The biology of Britain’s trees, native and introduced”. In: *Arboricultural Journal* 31, pp. 189–214.

Touzot, L., É. Schermer, S. Venner, S. Delzon, C. Rousset, É. Baubet, J.-M. Gaillard, and M. Gamelon (2020). “How does increasing mast seeding frequency affect population dynamics of seed consumers? Wild boar as a case study”. In: *Ecological Applications* 30.6, e02134. DOI: 10.1002/eap.2134.

van Beeck Calkoen, S. T. S., D. P. J. Kuijper, M. Apollonio, L. Blondel, C. F. Dormann, I. Storch, and M. Heurich (2023). “Numerical top-down effects on red deer (*Cervus elaphus*) are mainly shaped by humans rather than large carnivores across Europe”. In: *Journal of Applied Ecology* 60.12, pp. 2625–2635. DOI: 10.1111/1365-2664.14526.

Vergin, L., K. K. Clausen, and J. Madsen (2025). “The role of winter cereals as cold-weather refuge for Taiga Bean Geese *Anser fabalis fabalis* wintering in Denmark”. In: *Journal of Ornithology*. DOI: 10.1007/s10336-025-02262-8.

Wojewódzki Inspektorat Weterynarii (2019). *ASF w Polsce*. Data for 2014-2019. URL: https://www.wetgiw.gov.pl/nadzor-weterynaryjny/asf-w-polsce.

Zwolak, R., P. Celebias, and M. Bogdziewicz (2022). “Global patterns in the predator satiation effect of masting: A meta-analysis”. In: *Proceedings of the National Academy of Sciences* 119.11, e2105655119. DOI: 10.1073/pnas.2105655119.