

## **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**

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The size and density of the boar population, planned and actual harvest, and the level and nature of game damage were determined in the 2005/2006 and 2012/2013 seasons in forested regions leased by Hunting Club A (Mazovian Voivodeship) and Hunting Club B (West-Pomeranian Voivodeship). Clubs A and B leased hunting regions with areas of 10,250 and 12,000 ha, respectively, in which forested area constituted 42% and 70% and the fragmentation index was 2.82 km/km<sup>2</sup> and 0.48 km/km<sup>2</sup>. During the period analysed, the number of wild boars increased by 192% and 89% and their density by 200% and 91% in Club A and B, respectively. As the level of shooting in the regions was lower than planned, we can predict a further increase in the size of the population and progressive game damage to crops. The number of incidents of damage was greater in the 2012/2013 season than in the 2005/2006 in the Club A region, but lower in the Club B region, while the area of damage increased in both regions. The structure of the damage varied between seasons and regions. The occurrence of game damage in particular types of crops was linked to the stage of the growing season and to sowing. Differences were observed in Clubs A and B in the time when damage occurred in crops and in meadows and pastures. On the basis of the analysis and complex assessment of the indicators examined, we can predict an increase in the number and scale of incidents of game damage, particularly in Hunting Club A, in which the index of fragmentation of the forest complexes is nearly 6 times higher.

**KEY WORDS:** wild boar / population increase / game damage / types of crops

An increase in numbers of big game, and in particular in the Polish population of European boar (*Sus scrofa*), is responsible for the progression game damage, the number of such incidents and their distribution. Ninety percent of game damage in agricultural crops is caused by boar [9, 18]. Due to the damage to agriculture worldwide, interest in the ecology of this species is growing, and in particular in the dynamics and principles of population management [34].

A key element of the growth and evolution dynamics of a population is reproductive changes in the species [1, 5, 7, 8, 19, 32, 37]. The progression in the size of the boar population in Poland is due in part to climatic changes. The dynamics of population development and the proportions of age groups of females beginning reproduction vary depending on environmental conditions [1].

Indirect causes of the increased frequency of damage include changes taking place in the environment—both in forests, which are a refuge for big game, and in agriculture, including its intensification and crop structure. The European boar is a species that responds flexibly to changes in the availability of resources in its environment. Large maize fields chosen as refuges meet the animals' food preferences, which increases their migration from the forests to fields. The dynamics of game damage are also indirectly influenced by the management model of the boar population [10, 18, 27]. Access to high-energy food increases its reproductive potential [10, 11, 19, 25, 26, 30, 38]. This directly contributes to a dynamic increase in the population and indirectly to the number of incidents of damage and their extent [2, 12, 18, 20], which remains an unsolved and worsening problem [35]. The extent and spatial distribution of damage, as well as its intensity, are also affected by the number of game animals in a given area, the size and type of forest complexes, the degree of their fragmentation, which influences the length of the boundary between forests and fields, the time of year, crop distribution and the breakdown of use of agricultural land, intensification of agriculture, and urbanization [10, 12, 20]. The natural environment is subject to heavy exploitation by people. Boar, seeking to adapt to the new conditions created by human activity, change their behaviour, habits and dietary preferences. This results in game damage inflicted by animals of this species [9, 20].

The aim of the study was to compare the extent of game damage and the types of crops affected based on the example of two hunting clubs leasing forested hunting districts located in different regions of the country (Mazovian Voivodeship – Hunting Club A, West Pomeranian Voivodeship – Hunting Club B) from 2005 to 2013.

### **Material and methods**

An analysis was made of changes in the population size and density of boar in two Hunting Clubs, A and B, located in the Mazovian and West Pomeranian Voivodeships. The length of the field-forest boundary and the size of the harvest of the population living in hunting districts leased by Clubs A and B were determined. The extent of game damage was compared and the types of crops in which it occurred were specified. To identify the critical periods when crops are particularly at risk of game damage, the time when game damage occurred in different crops was determined.

Numerical data concerning the area of the hunting districts and the forested area in them, as well as the size of the boar population and the planned and actual harvest of the species, were obtained from documentation conducted by the leaseholders of the areas. The length of the field-forest boundary was measured with an electronic map measurer (Silva Plus) on topographic maps with a scale of 1:50,000. State-owned and private fo-

rests were taken into account in measuring the field-forest boundary. The fragmentation index of the forest complex ( $\text{km}/\text{km}^2$ ) was calculated as the quotient of the length of the field-forest boundary (km) and the forested area ( $\text{km}^2$ ) for the two hunting districts.

From the protocols of initial and final estimation of damage prepared by the leaseholders of the districts in which damage occurred, data were obtained on the size of the reduced area and the time the damage occurred in each crop (Hunting Club A – data from 2006 and 2013; Hunting Club B – data from 2006 and 2013) [21, 22, 23, 24]. Procedures for estimating damage inflicted by wild animals in crops were based on the Regulation of the Minister of the Environment of 15 July 2002 [31].

## **Results and discussion**

During the hunting seasons analysed Hunting Club A leased one hunting district, with an area of 10,250 ha, in the northern part of the Mazovian Voivodeship. Forested area accounted for 42% of the district. According to current classification principles, this qualifies the district as a forest district. The most commonly encountered game animals in the district were roe deer, European boar, red deer, foxes, raccoon dogs, badgers, hares and elk; in the final year the appearance of the first fallow deer was noted. The crops most frequently cultivated in the district were maize, wheat, rye, oat, barley, rapeseed and potatoes.

Hunting Club B leased one forest district in the West Pomeranian Voivodeship during the study period, with an area of about 12,000 ha. Forests account for 70% of the area of the district (together with meadows within forests and hunting food plots). The crops most frequently cultivated in the district were maize, rapeseed, wheat, rye and oat, and rarely potatoes.

The extent of game damage is influenced by the field-forest boundary; the longer it is, the greater the fragmentation of the forest complex. A high degree of fragmentation of forest complexes is conducive to the presence of boar [33]. In the districts compared in the study the fragmentation index of the forest complexes was varied: 2.82  $\text{km}/\text{km}^2$  and 0.8  $\text{km}/\text{km}^2$  for Hunting Clubs A and B, respectively. The forested area in the district in the West Pomeranian Voivodeship is one dense forest complex, in contrast with the forested area in the district located in the Mazovian Voivodeship.

Following the study period (2005/2006 – 2012/2013) an increase in the number of boar was recorded in the hunting districts leased by Hunting Clubs A and B. In Hunting Club A the population increased by 192% and in Hunting Club B by 89% (Tab. 1). At the same time, in both clubs (A and B) an increase was noted in the density of the species on 1,000 ha of forested area, by 200% and 91%, respectively. The Supreme Hunting Council, in an annex to Resolution 57/2005 of 22 February 2005, does not clearly indicate the optimal density of boar on 1,000 of forested area [29]. Boar density should be high because they constitute an element of forest protection by reducing the occurrence of pests that damage trees [29]. Maintenance of high boar density, however, generates game damage, while the financial capabilities of the leaseholders of the districts are limited.

**Table 1**

Changes in the size and density of wild boar populations and in planned and actual harvest in Hunting Clubs A and B during the 2005/2006 and 2012/2013 hunting seasons

Trait	Hunting Club A		Hunting Club B	
	2005/2006	2012/2013	2005/2006	2012/2013
Size of wild boar population (head)	50	146	315	601
Number of wild boar per 1,000 ha	5	15	36	69
Planned harvest of wild boar (head)	25	73	160	300
Actual harvest of wild boar (head)	21	26	160	198

The game harvest plans prepared by the hunting district managers in the 2005/2006 season anticipated culling of 50% of the estimated boar population. Hunting Club A achieved 84% of the planned harvest of the game species, while Hunting Club B achieved 100%. In the 2012/2013 hunting season the actual harvest was 35% and 66% in the respective clubs (Tab. 1). The low harvest was conducive to an increase in the population and density of animals in the regions belonging to the two clubs in the seasons compared in the study (Tab. 1). In 2000-2013 the mean harvest of this species in the country was about 79%. This level of boar culling did not lead to stabilization of the population size in Poland [19]. Due to the lower culling than planned in the districts we can predict a further progression in game damage to crops. It also appears that the scale of the problem will be considerably greater in Hunting Club A, due to the nearly six-fold higher fragmentation index of forest complexes.

In the 2012/2013 hunting season, as compared to the 2005/2006 season, the size of the area reduced by boar feeding in the district leased by Hunting Club A increased by about

**Table 2**

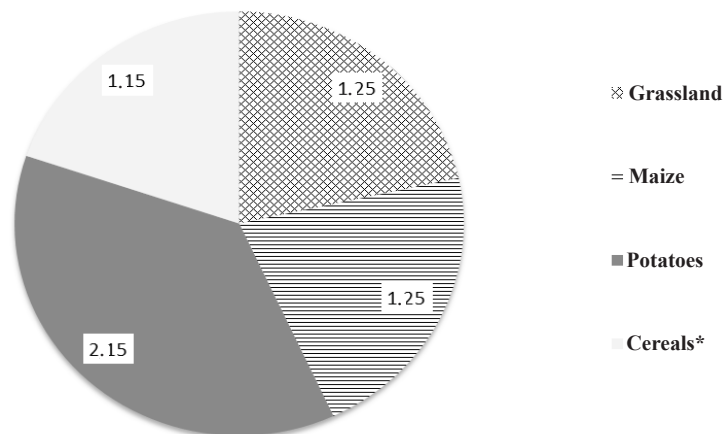
Size of the reduced area (ha) caused by wild boar in the 2005/2006 and 2012/2013 hunting seasons (Hunting Club A – Mazovian Voivodeship, Hunting Club B – West-Pomeranian Voivodeship)

Hunting Club A		Hunting Club B	
hunting season	total reduced area (ha)	hunting season	total reduced area (ha)
2005/2006	5.80	2005/2006	14.93
2012/2013	11.10	2012/2013	22.05

91% (Tab. 2). In Hunting Club B the reduced area in the 2012/2013 season increased by about 48% with respect to the first season (Tab. 2).

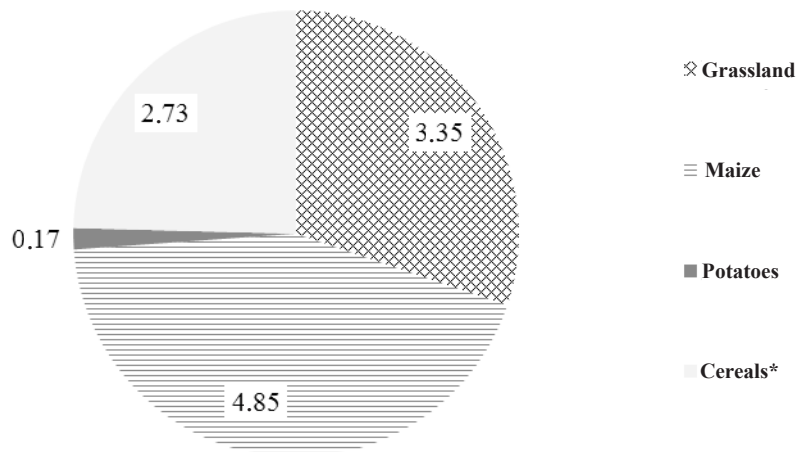
Figures 1 and 2 present the change in feeding preferences of boar in the 2005/2006 and 2012/2013 hunting seasons in Hunting Club A. In the 2005/2006 season damage by boar occurred in four types of crops. Damaged potato crops, maize crops and grassland accounted for about 37%, 22% and 22%, respectively, of the reduced area. Destruction of maize was considered separately because of the upward trend in sowing due to the nutritional and habitat qualities of the plant. According to data from the Central Statistical Office (GUS) [16, 17], the area of maize cultivation in the country in 2013 increased in comparison to 2005/2006 and was over one million ha (including about 613,000 of maize for grain and about 480,000 for silage). The area of potato cultivation decreased twofold, to about 270,000 ha. With respect to the 1990s, the decrease in the area of potato crops was more than fourfold [15, 17]. In consequence, the occurrence of game damage in these crops decreased substantially.

In the 2012/2013 hunting season destruction in potato crops in Hunting Club A accounted for only 1.5% of the total reduced area. With respect to the 2005/2006 farming year the decrease in damage was about 92%. A marked increase in damage was noted in cereals. In the 2012/2013 season about 3 ha of cereals were destroyed, which was nearly a quarter of the damage occurring in this season in all types of crops. The level of damage to cereals rose by about 130% with respect to the first season. Grassland accounted for one third of



\*Without maize

Fig. 1. Percentage of individual types of crops (ha) in the reduced area (ha) caused by wild boar during the 2005/2006 hunting season in Hunting Club A



\*Without maize

Fig. 2. Percentage of individual types of crops (ha) in the reduced area (ha) caused by wild boar during the 2012/2013 hunting season in Hunting Club A

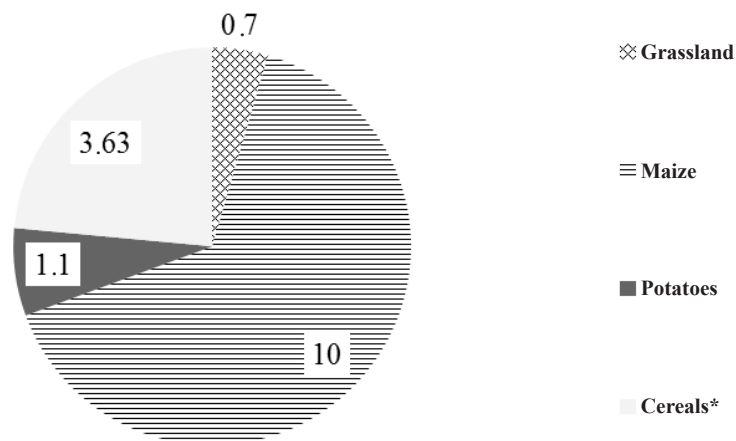
the total reduced area; an increase of about 168% was noted in the extent of damage with respect to the 2005/2006 season. The largest reduced area in the last hunting season analysed was noted in the maize crops. As the area of maize cultivation increased the extent of damage in the 2012/2013 season rose by 288% in comparison with the 2005/2006 season (Figs. 1 and 2).

In the 2005/2006 season the least damage inflicted by boar was noted in the grasslands—only 4.7% of the reduced area in the district leased by Hunting Club B (Fig. 3). Somewhat greater damage occurred in the potato crops, accounting for 7.4%.

In the 2005/2006 season the reduced area in cereals (except for maize) was 24.3% of the total reduced area. This is over 100% more than in Hunting Club A in the same season. In Hunting Club B maize was the most popular crop among boar, in contrast with Club A, in which the greatest damage in the 2005/2006 season was noted in potato crops.

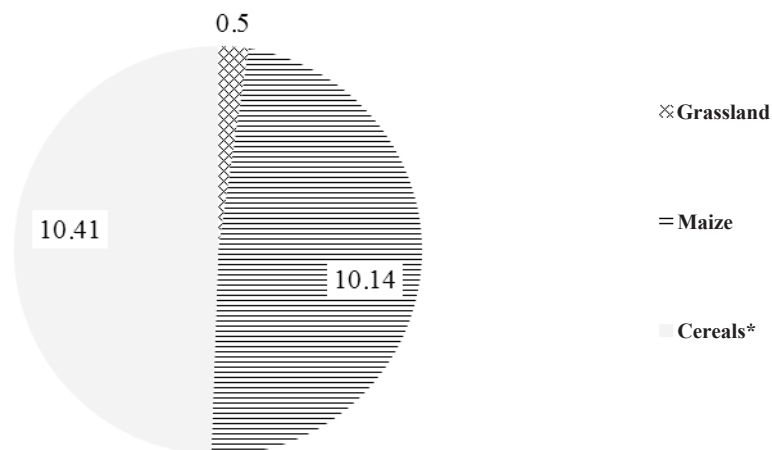
After eight hunting seasons a change was observed in the size of the reduced area in different types of crops, together with a change in the feeding preferences of boar in this region of the country (Fig. 4). In season 2012/2013 no damage was noted in potatoes, while the greatest damage was observed in cereal crops (an increase of 6.78 ha in the 2012/2013 season vs. 2005/2006) – Fig 4.

Changes in the mean area of game damage (ha) and the frequency of incidents of damage (n) caused by boar in different crops in 2005–2013 in Hunting Clubs A and B are present-



\*Without maize

Fig. 3. Percentage of individual types of crops (ha) in the reduced area (ha) caused by wild boar during the 2005/2006 hunting season in Hunting Club B



\*Without maize

Fig. 4. Percentage of individual types of crops (ha) in the reduced area (ha) caused by wild boar during the 2012/2013 hunting season in Hunting Club B

ted in Table 3. During this period in Club A, together with the change in the reduced area in individual types of crops a change was noted in the frequency of damage and the size of a single incident of damage. In Club B the differences noted in the size of a single incident and in the number of incidents were small. The greatest changes were noted in cereals; an increase of over 300% was observed, while the number of incidents reported decreased by 3. The total number of cases of game damage reported in all types of crops decreased by 7, while the area reduced by boars in the district leased by Club B increased.

**Table 3**

Changes in mean area of game damage (ha) and frequency of damage (n) caused by wild boar in individual types of crops in the years 2005-2013 in Hunting Clubs A and B

Type of crop	Hunting Club A				Hunting Club B			
	mean area of damage (ha)				mean area of damage (ha)			
	2005/2006		2012/2013		2005/2006		2012/2013	
	ha	n	ha	n	ha	n	ha	n
Grasslands	0.31	4	0.42	8	0.35	2	0.50	1
Maize	0.31	4	0.70	7	2.50	4	2.02	5
Potatoes	0.50	5	0.04	4	0.37	3	–	–
Cereals*	0.39	5	0.45	6	0.36	10	1.49	7
Total	–	18	–	25	–	19	–	13

n – number of incidents of damage

\*Without maize

There are many factors strongly influencing the extent of damage, its spatial distribution, and its intensity. These include the number of game animals in a given region and the size, type and degree of fragmentation of forest complexes, which determines the boundary between the forest and field. Another factor is seasons of the year, which determine the growth and development of crop plants (Tab. 4). The degree and extent of damage is strongly associated with crop distribution and the breakdown of agricultural land use [10].

Intensification of agriculture and progressive urbanization of natural areas which are refuges for wild animals reduces the land they naturally inhabit [12]. This leads to changes in their behaviour, their choice of feeding grounds, and reproduction. The problem is aggravated by human impact on forested areas and crops. All of these factors directly or indirectly affect the occurrence of game damage and its intensity, spatial distribution and scale.



**Table 4**

Percentage share of damage to crops during the growing season (March – November)

Month	Hunting Club A				Hunting Club B			
	UZ	KK	ZM	ZB	UZ	KK	ZM	ZB
III	25	–	–	–	–	–	–	–
IV	17	–	–	9	–	–	–	12
V	25	18	11	–	33	–	–	–
VI	–	–	11	–	33	–	67	–
VII	–	–	–	18	–	–	–	47
VIII	–	–	22	73	–	–	–	41
IX	–	55	33	–	34	–	33	–
X	8	27	23	–	–	89	–	–
XI	25	–	–	–	–	11	–	–

UZ – grasslands, KK – maize, ZM – potatoes, ZB – cereals (without maize)

Due to an increase in human impact factors in the forest, which is the natural biotope of boar, the food base has become impoverished, leading the animals to relocate to crop fields. The fields are used as feeding grounds, which results in game damage. The intensity of this phenomenon varies in different regions of the country, but is progressive practically everywhere. Changes in the extent of game damage in Poland are linked to the size of the boar population. A decrease in the size of the population is beneficial, because the scale of damage to crops is smaller. The extent of damage also depends on hunting pressure on the species and on its population structure, as well as the structure of forest complexes and the length of the boundary between forests and fields [2, 12, 13, 18, 19, 20].

Apart from culling of boars, fields can be protected from excessive game damage by visual, auditory and tactile methods, included among mechanical methods, as well as by chemical methods. An integration of methods is most effective, as was confirmed in the hunting district leased by Hunting Club B in the West Pomeranian Voivodeship. Owing to the use of these methods game damage to maize crops was eliminated during the sowing period and the extent of the damage was stabilized in maize crops in the course of the eight (2005-2013) hunting seasons analysed.

European boar is a species determining the economic significance of damage inflicted by game animals. During the growing period of plants these animals become mainly herbivores oriented towards consumption of crop plants. Over the last few decades the feeding preferences of boars have become modified due to changes in the structure of agrocoenoses. The acreage of large-area cultivation of crops has increased, together with an increase in the proportion of high-energy crops. In the 1970s and 1980s the main plant fed on by boars in crop fields was potato [4, 14, 28], but it was replaced by maize at the end of the 1990s [6, 10, 35]. This is the plant with the leading position in the chain of the boar's feeding preferences [35]. According to data from the Central Statistical Office (GUS) [17], in 2013 maize was cultivated in Poland on a surface of about 1,043,200 ha. Maize residue mixed in with the top layer of soil attracts boars to fields, which additionally magnifies

damage in May, when maize and other follow-up crops are sown [35, 36]. Because maize grows very tall, animals feeding in it feel exceptionally safe and confident, so that chemical or physical deterrents have almost no effect [36]. No repellent provides 100% protection of crops against the destructive activity of boar [35].

A key element of the dynamics of the growth and evolution of the boar population, a species largely responsible for game damage, is reproductive changes [32]. The age when land vertebrates begin to reproduce is closely correlated with the moment when the female achieves a threshold body weight above which she is able to reproduce successfully [1]. In comparison with other ungulates, the threshold weight of the boar is low, at about 30 kg, which is only 30-45% of the weight of an adult individual [7, 8]. Servanty et al. [32] report that 80% of juvenile sows under one year of age reach the minimum threshold body weight and begin reproduction. Bieber and Ruf [1] demonstrate that even females weighing 20 kg are able to begin reproduction and give birth to their first litter. The low threshold weight above which individuals are able to successfully reproduce, together with hunting pressure on the species, directly contributes to an increase in the population [32].

Variation in the age at which females attain the threshold body weight is largely influenced by climate conditions, habitat quality, and population density. The development dynamics of an animal population are influenced by the source of energy used by the animal for reproduction. In the European boar, pregnant females use only a small portion of the reserves accumulated during the summer and autumn months before the reproductive period. For the growth and development of the foetus and to meet production needs they use energy supplied from day to day [32]. Demographic changes in the population are strongly influenced by the fact that the female boar can give birth at the age of under one year, whereas other animals first give birth in their second or third year. The female boar also gives birth to an average of five young, while other ungulates give birth to only one [32]. Bieber and Ruf [1] and Zawadzki et al. [37] report that the beginning of sexual maturity in female boar largely depends on the availability of food resources in the environment, and these, even when there is a temporary lack of acorns and beechnuts, are supplemented or replaced by food from crop plants. Reproduction outcomes are also influenced by the social structure of the group [3, 26]. Dietary flexibility and the continual growth of the population of the species is the basis of the problem of game damage, the extent of which is increasing.

To sum up, in the forested areas of the hunting districts leased by Hunting Clubs A (Mazovian Voivodeship) and B (West Pomeranian Voivodeship) during the period analysed (2012/2013 vs 2005/2006 hunting seasons) a significant increase in the size and density of the European boar population was noted, by 192% and 89% for population size and by 200% and 91% in the case of density. In the district belonging to Club A, the fragmentation index of forest complexes in the 2012/2013 season was six times higher than in the district belonging to Club B. The actual culling of boar in the Clubs was much lower than the level planned by the leaseholders, which presumably contributed to the increase in the population size of the species and the progression of the phenomenon of game damage. In the two hunting districts leased by Hunting Clubs A and B the type of crops destroyed was different and varied over time. In the 2005/2006 hunting season

in the district leased by Hunting Club A the greatest destruction was noted for potato, followed by grassland, maize and cereals. In the 2012/2013 hunting season the greatest damage was noted in grasslands, followed by maize, cereals and potatoes. Game damage occurred from March to November. In the district leased by Club B the order and magnitude of damage in the 2005/2006 season were different; the greatest damage was noted for maize, followed by cereals, potatoes and grassland. In the 2012/2013 season the greatest damage was noted in cereals and maize, with little damage to grassland and none to potato. The occurrence of game damage in different kinds of crops was linked to the period of the growing season and to sowing. In Hunting Clubs A and B differences were noted in the time when damage caused by boar occurred in crops and in meadows and pastures.

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