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**Intensity of damages made by wild boars under diverse  
environmental conditions on a background of the population  
dynamics**

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Intensywność występowania szkód wyrządzonych przez dziki w zróżnicowanych warunkach środowiskowych, na tle dynamiki liczebności populacji

**Summary.** The study aimed at analyzing the size and distribution of damages made during 6 hunting seasons taking into considerations the hunting management of the wild boar population, as well as the influence of the diversity of environmental conditions on the size of damage and the animals' preying preferences, within two hunting circuits localized on the studied area. Both hunting circuits are situated on the Lublin Upland and are leased by the same hunting circle, which causes that all nursery treatments associated with the hunting management are similar. A dynamic increase of damages in the cultivation of cereals and maize crops, as well as on permanent grasslands occurred during the studied period. On the other hand, relative stabilization of the damage size was observed within root crops. The calculated indices of animals' preying preferences indicated that permanent grasslands and maize became the most preferred crops, while cereals were characterized by the least preying attractiveness for animals. The analysis of the dependence between the size and shape of forest complexes revealed that, under the present environmental conditions of agrocenoses, this factor has no remarkable effect on the size of damages in agricultural crops. Meanwhile, the calculated dependencies between wild boar population and damage dimensions within the crops indicated that there was a high and statistically significant correlation between the increase of wild boar population and an elevated damage size made in agricultural crops.

**Key words:** hunting damages, agricultural cultivations, food preference, wild boar

INTRODUCTION

A progressive increase in the number of large wild game has been observed both in Poland and in most European countries during the last several years, and thus the occurrence local densities of some species has become extremely high. The most dynamic

growth of population number concerns wild boars, for which the realized gain amounts at present to 150-200% of the spring population [Budny *et. al.* 2010, Kamieniarz 2010, Flis 2011b]. The main reason for this phenomenon refers to habitat changes in fields in the form of increasing the large crops areas in combination with the dominant role of maize crops as the primary forage plant. These environmental factors contribute to the extensive colonization by wild boars of vast agrocoenosis, in which the animals find the high-energy prey basis for larger part of the year, as well as excellent shielding conditions. These elements make specific behavioral changes as well as physiological ones, that are manifested as early maturing, and thus readiness of young females for breeding and increased litters, as well as specific sexual cycle dis-regulation resulting in giving a birth by females during almost the whole year [Kozdrowski and Dubiel 2004, Flis 2009a]. All of these elements affect directly and indirectly, as well as in a complex manner, the degree of interactions between animals and their living environments, which in economic terms is referred to as damages to crops and agricultural products. An indirect cause of the increase in crop damage also includes more intensive environmental changes occurring in forest phytocoenoses, which until recently, are the primary place for large wild game living, including wild boars, which in turn are the primary culprit of agricultural crops damages [Fruziński 1993, Flis 2009b, Flis 2010a].

The differentiation in size and the spatial distribution as well as the distribution of damages in annual cycles, is directly related to the size of wild boar population in a given area as well as the hunting pressure on this species, which conditions the regulation of population size and structure. Additional factors that affected the amount of damages were: number and size of forest areas, and their spatial distribution determining the length of the field-forest boundary influencing directly on the amount of damages, especially in the case of crops in the vicinity of a forest [Mackin, 1970, Drozd 1988, Dubas 1996, Łabudzki and Wlazelko 1991, Flis 2009b, Flis 2010a]. The responsibility for damage caused by wildlife is varied and depends on the species, which is the cause of the damage and the location of damaged crops. Currently, the damages caused by four animal species (wild boar, deer, fallow, and roe deer) and resulting within the area of hunting circuits, are the responsibility of a leaseholder or manager. In other areas, this responsibility is transferred to the legal owner of the game, i.e. the Treasury [Flis 2008, Flis 2009a, Flis 2010b, Flis 2011a, Flis 2011d].

The aim of this study was to analyze the size and distribution of damages during six hunting seasons, including hunting management of wild boar population, as well as impact of environmental variations on the size and prey preferences of animals within two areas of the research.

#### MATERIAL AND METHODS

The study was carried out on the basis of the field procedures for the liquidation of damages caused by wild animals to crops and agricultural products, in two hunting circuits with diverse environmental conditions. These procedures consist of a preliminary assessment of particular damage performed by an authorized representative of the leaseholder or manager of the hunting circuit, and the final damage assessment, including activities aimed at determining the amount of compensation entitlement. The study con-

tains the concept of a surface of reduced damage, which is calculated in a form of surface index considered as a surface, on which the damage occurred in 100%.

Making this type of analysis allows for an objective comparison of the surface distribution of various damage types in agricultural crops. The indicator of agricultural crops prey preference was also determined, which is commonly used in this type of study. This parameter was calculated by dividing the difference in the percentage of damaged crops and the approximated percentage of a given crop in the crop structure, by the percentage of a given crop in the crop structure, according to the following formula:

$$W_p = \frac{a - b}{b}$$

$W_p$  – prey preference indicator;

$a$  – percentage of damaged crop;

$b$  – percentage of a given crop in the crop structure.

Positive values indicate the preference for certain plants in crops by wild boars, while when the value of the indicator approaches zero, or has negative values, it points to ambivalent treatment or even avoidance of specific crops by animals.

In addition, the area of forest complexes occurring in the hunting circuit was evaluated, as well as length of the field-forest boundary and index of the forest fragmentation within particular circuits, was assessed using topographical maps of these hunting circuits. To present the relationship between the presence of forests and their spatial distribution as well as the size and shape vs. degree of crop damages due to animals, the distribution of damages are presented in graphical form.

Data from the hunting documentation on the number and hunting acquisition of wild boars were also used, which served for calculating the relationship between wild boar population dynamics and the size of damages to crops.

#### STUDY AREA

The study area consisted of two hunting circuits localized in the north-eastern part of the Lublin Upland. These circuits are leased by the same circle hunting, and thus the standard of game management is similar. The first studied hunting circuit is the administrative circuit No 136. with a total area of 5,000 ha, of which forests constitute 26.6%. According to the hunting classification, it is recognized as a very weak field circuit. The second circuit is the administrative circuit No. 137 with a total area of 7000 ha and it is the weak forest circuit, the share of forest lands within this circuit is 57%. Both circuits border to each other along the road S-17 (Figure 1), while its northern boundary is the meandering Wieprz river. Additionally, in the central part of the hunting circuit No. 137, there is a nature reserve "Piskory", which is a remnant of a former lake. Due to location in Lublin Upland region, both circuits are characterized by crops with high soil requirements. At the same time, because of the very developed intensification of agricultural production combined with remarkable fragmentation of forests, especially in the hunting circuit No. 136, the area under

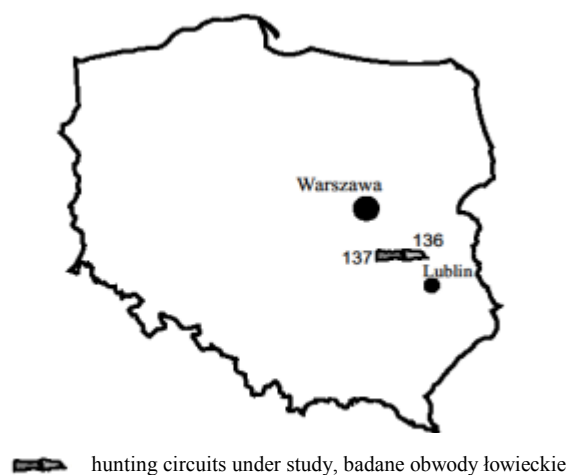


Fig. 1. Location of study area  
Rys. 1. Lokalizacja terenu badań

study is characterized by a fairly significant differences of agrocoenotic structures, especially high environmental fragmentation [Kondracki 2000, Witek 1991]. The calculated index of forest fragmentation of expressing the ratio of the circumference to the surface of forests amounted to 5.81 for the field-character circuit No. 136, which was over twice as high as for the forest circuit No. 137, for which this parameter was 2.56.

## RESULTS

Both quantitative and surface increase in damages made by wild boars to cereal crops in both hunting circuits was reported during the 6 studied hunting seasons (Fig. 2). Within the hunting circuit No. 136, the amount of damages in terms of the surface was small in the first five seasons of hunting, whereas in the last season, 9.65 ha of crops were damaged. Thus, evaluating the entire study period, over 300-fold increase in damages was recorded in this circuit. Within the hunting circuit No. 137 in the same period, despite of fluctuations in particular seasons, there was a little more than 2.5-fold growth in terms of the surface damages. An increase in damage to maize, both quantitative and surface terms, was observed only in the field hunting circuit No. 136. Considering the hunting circuit No. 137, the amount of damages in the surface terms was much smaller in all hunting seasons and showed a downward trend (Fig. 3). The dynamics of the increase in the surface damage to permanent grassland varied in both studied hunting circuits during the research (Fig. 4). Almost 4.5-fold increase in the area of damaged crops was recorded in hunting circuit No. 136, while nearly double increase was present in hunting circuit No. 137. It is worth emphasizing the hunting season 2009/10, when a record number of this type of crop damage was recorded in both hunting districts. The size of damages to root crops was low and did not exceed 1.5 hectares of reduced surface during the research (Fig. 5). At the same time, the fluctuating characteristics of these damages allows for concluding that in the case of damages to this type of grassland areas, a kind of stability with a

small upward trend occurred in hunting circuit No. 136 during the evaluation. In hunting season 2009/10, damages covering a total area of 1.42 ha of reduced surface, were liquidated, which was more than the total area of damages in the other seasons within that hunting circuit. All the damages under liquidation were caused by wild boars.

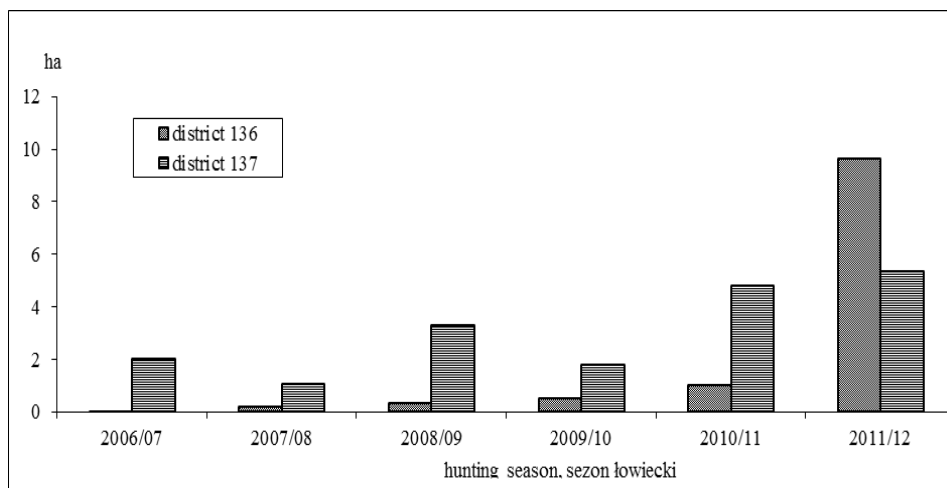


Fig. 2. Distribution of damages in cereals during the 6 years of study  
Rys. 2. Rozkład szkód w uprawach zbożowych w ciągu 6-letniego okresu badań

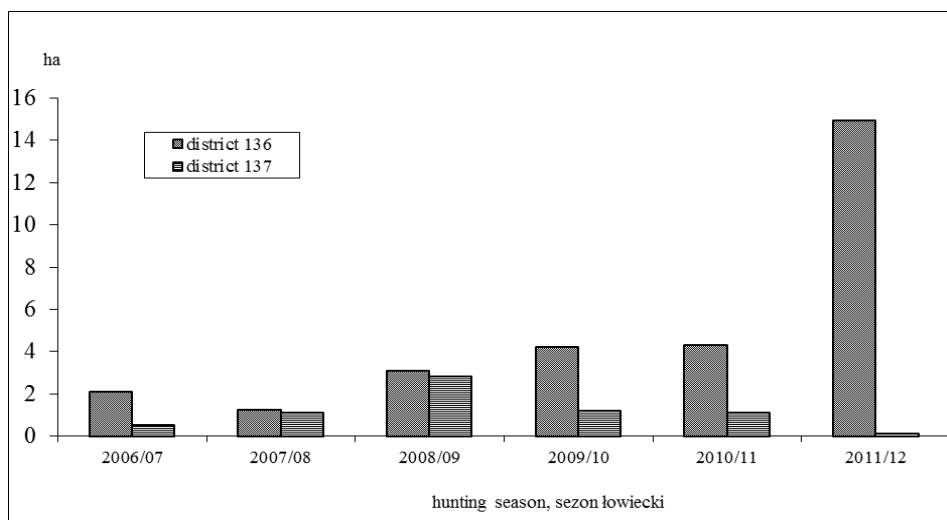


Fig. 3. Distribution of damages in maize during the 6 years of study  
Rys. 3. Rozkład szkód w uprawach kukurydzy w ciągu 6-letniego okresu badań

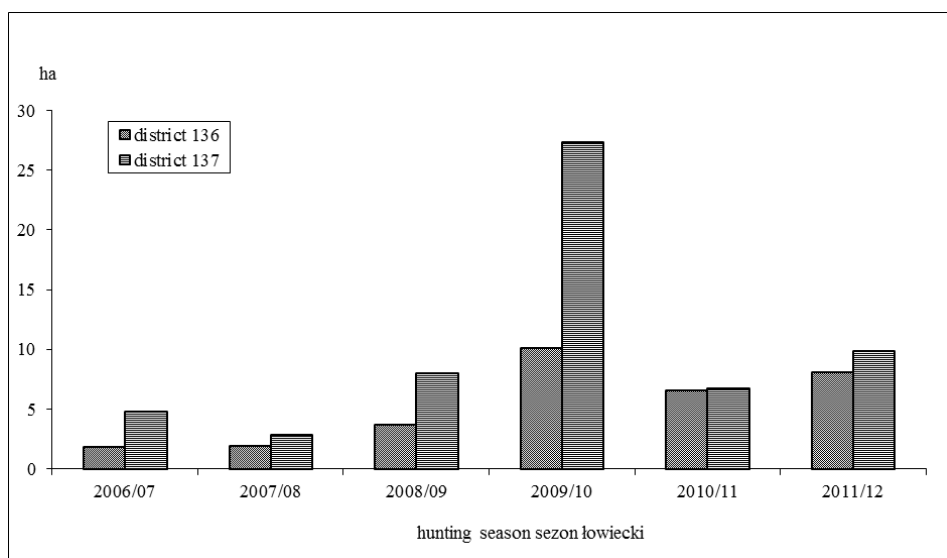


Fig 4. Distribution of damages in on permanent grasslands during the 6 years of study  
Rys. 4. Rozkład szkód na trwałych użytkach zielonych w ciągu 6-letniego okresu badań

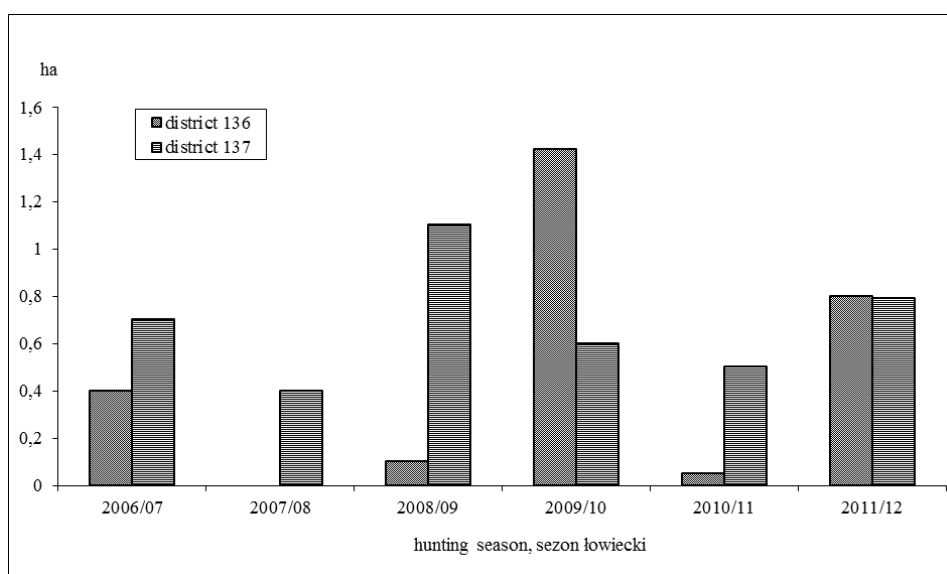


Fig. 5. Distribution of damages in root crops during the 6 years of study  
Rys. 5. Rozkład szkód w uprawach roślin okopowych w ciągu 6-letniego okresu badań

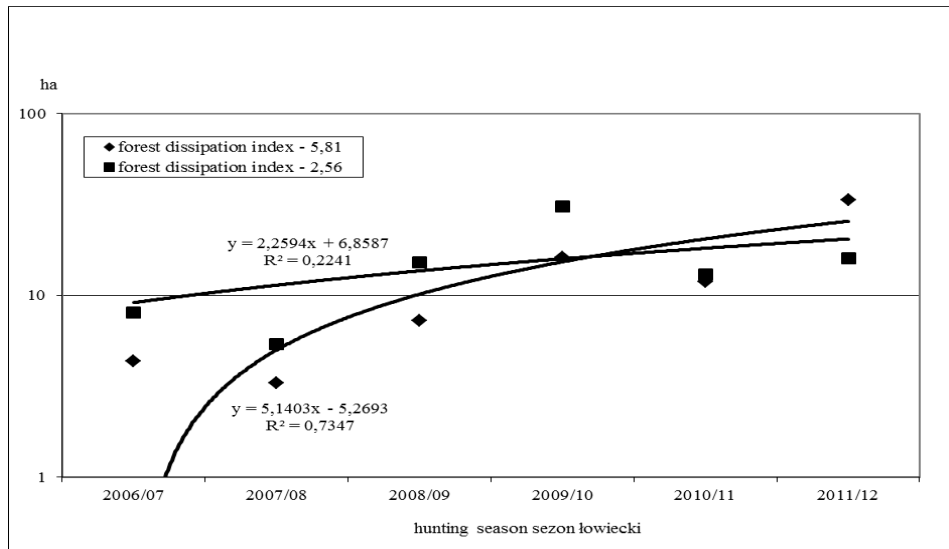


Fig. 6. Distribution of damages in particular hunting seasons on a background of forest dissipation index

Rys. 6. Rozkład szkód w poszczególnych sezonach łowieckich na tle wskaźnika rozdrobnienia kompleksów leśnych

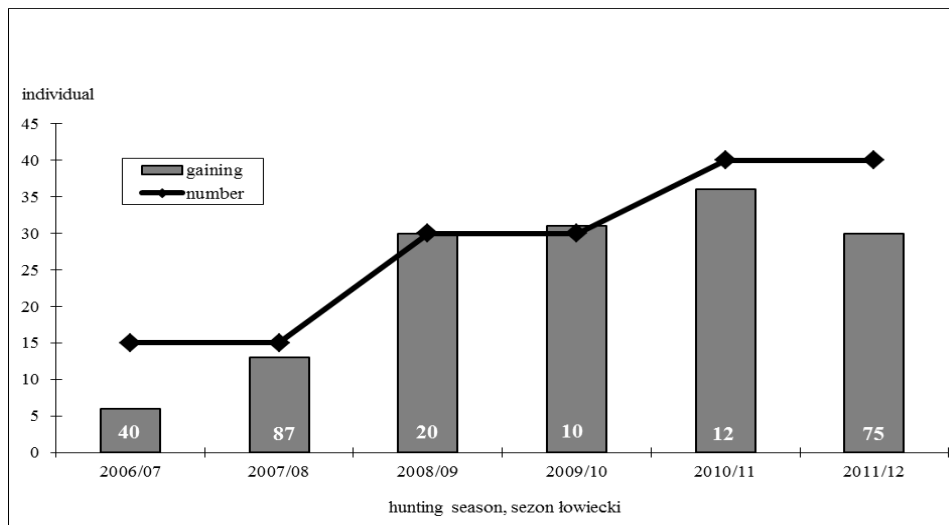


Fig. 7. Characterization of hunting management over wild boar population within hunting circuit No 136

Rys. 7. Charakterystyka łowieckiego gospodarowania populacją dzików w obwodzie łowieckim nr 136

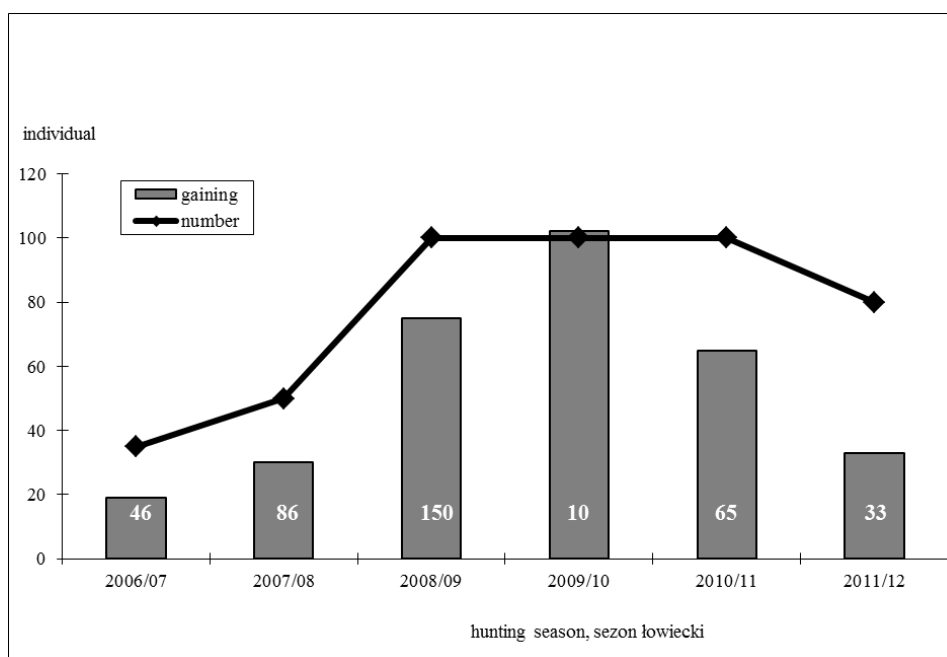


Fig. 8. Characterization of hunting management over wild boar population within hunting circuit No 137

Ryc. 8. Charakterystyka łowieckiego gospodarowania populacją dzików w obwodzie łowieckim nr 137

Table 1. Indices of prey attractiveness of crops in hunting seasons 2006/07-2011/12  
Tabela 1. Wskaźniki atrakcyjności żerowej roślin uprawnych w sezonach łowieckich 2006/07-2011/12

Type of cultivation Typ uprawy	Number hunting district Numer obwodu łowieckiego	
	136	137
Cereal (totality) Zboża (razem)	-0,72	-0,60
Corn Kukurydza	1,30	-0,23
Root crops Ziemniaki	-0,40	-0,34
Sustainable green lands Użytki zielone	0,91	1,09

Calculated indices of the prey attractiveness for particular types of crops indicate that quite significant differences in prey preferences occurred in studied areas (Tab. 1). Within the hunting circuit No. 136, the most preferred plant was maize, for which the



preference index reached the positive value of  $W_p = 1.30$ . Permanent grasslands were another crop preferred by wild boars, for which the preference index reached  $W_p = 0.91$ . The root crops, for which the prey preference index reached negative value ( $W_p = -0.40$ ), were subsequent plants regarding to the index. Cereals were the least preferred, because the prey preference index amounted to  $-0.72$ . In the circuit hunting No. 137, that was characterized by much higher humidity, wild boars mostly preferred the permanent grasslands, for which value of the index was 1.09. For other types of agricultural crops, in which damages occurred, the prey preference index reached negative values. Wild boars preferred (in descending order) maize ( $W_p = -0.23$ ), root crops ( $W_p = -0.34$ ), and cereals ( $W_p = -0.60$ ).

The overall assessment of damage caused by wild boars in different hunting seasons including the index of forests fragmentation indicates that this fragmentation does not significantly affect the amount of damage to agricultural crops, and even vice versa (Fig. 6). An increase in damages caused by wild boars occurred in both hunting circuits during the study period, which is confirmed by the trend lines and directional factors. Calculated values of Pearson linear correlation coefficients suggest that at greater fragmentation of forests (hunting circuit No. 136), higher linear dependence of the upward trend was present in damages to agricultural crops ( $R^2 = 0.7347$ ). In the hunting circuit No. 137 characterized by greater compactness of forests, this relationship was smaller amounted to  $R^2 = 0.2241$ .

The increase in the number of wild boars population was recorded during the study period in both districts (Fig. 7 and 8). Within the hunting circuit No. 136, more than 2.5-fold increase in the population occurred, while in hunting circuit No. 137, an increase in the wild boars number from 35 to 100 animals was observed in six seasons; surprisingly 20% decline was reported in the last as compared to the previous hunting season. At the same time, a successive increase in the hunting acquisition occurred in hunting circuit No. 136. Six wild boars were acquired in the hunting season 2006/07, which in relation to the spring population accounted for 40%. This increase continued until the hunting season 2010/11, when the total acquisition was 36 animals, and the index of hunting exploitation of the population amounted to 120%. In the last hunting season, the acquisition amount was 30 animals, and hunting exploitation of the population during this period oscillated around 75% of its spring level. It is worth emphasizing that during hunting season 2008/09, the index of hunting exploitation of the population reached a value of 200%. The annual increase in the hunting acquisition maintained in hunting circuit No. 137 in seasons 2006/07–2009/10. Index of hunting exploitation of the population during this period was in the range 46–150% of its spring level. In the following two hunting seasons, the acquisition amount decreased, and a total of 33 wild boars were acquired the last season in that hunting circuit; the index of hunting exploitation of the population reached 33% of estimated spring population. Such level of hunting exploitation of wild boars is rather low, thus it directly affects the standard dynamics of the species population.

The calculated correlation coefficients between the number and size of the damage in particular hunting seasons indicate a high degree of correlation between these parameters. In hunting circuit No. 136, the correlation coefficient between the population of wild boars vs. the extent of damages expressed as the size of reduced area amounted to  $R_{xy} = 0.736$ , which was significant. A similar situation occurred in the hunting circuit No.

137, in which the correlation coefficient reached a value of  $R_{xy} = 0.691$ , which was also significant.

Achieved results are a confirmation of the thesis of the rapid increase in wild boars population, not only in the region of Lublin Upland, but also the whole country, which in turn determines the increased level of interaction with the living environment, mainly diverse structures of agrocenoses [Budny *et. al.* 2010, Kamieniarz 2010, Flis 2011b, Flis 2012]. Along with increasing intensification of agriculture and the emergence of maize plantations, the prey preferences of wild boars have changed. This condition contributed to changes in reproductive processes, and thus a dynamic growth of population [Kozdrowski and Dubiel 2004].

#### DISCUSSION

In the 60's of the last century, the basic prey crops for wild boars were growing potatoes and oats [Mackin 1970]. Similar results were reported by Drozd [1988], who conducted a research in the 70's and 80's of the last century in east-central macro-region of Poland, as well as Łabudzki and Wlazelko [1991] in studies carried out in the Wielkopolska. In the mid of 80's, in western parts of the country, the prey preferences of wild boars directed towards more commonly grown maize [Wlazelko and Łabudzki 1992]. However, in the 90's, the maize plantation became dominating in terms of wild boar's prey preferences [Dubas 1996]. According to studies performed by Flis at the beginning of 2000 in the Lublin Upland, growing maize, then permanent grasslands, where animals searched for animal-origin prey, were at the top of the prey preferences chain [Flis 2009b, Flis 2010a, Flis 2011c]. Similar prey preferences of wild boars are also found in other European countries. Studies conducted in the late nineties and early 2000 in the north-eastern Spain and Luxembourg confirmed that in the chain of wild boar's prey preferences, maize cultivations are at the first place [Herrero *et. al.* 2006, Schley *et. al.* 2008].

The established relationship between the degree of forest fragmentation and wild boar population vs. size of the damage to agricultural crops, confirm the thesis of many authors that the primary factor affecting the amount of damage is the wild boar population and the fragmentation of forests favors the functioning of wild boar population in recent years, and the fragmentation of forests has recently favored good functioning of wild boar population [Mackin, 1970, Drozd 1988, Dubas 1996, Flis 2009b, Flis 2010a, Czyżowski *et. al.* 2011, Flis 2011c, Flis 2011d].

Results achieved within selected environments of Lublin Upland are somehow a confirmation of the whole-country increasing trends in the number and size of damages made by wild boars in agrocenoses, both in south-eastern macro-region of Poland, and other parts of the country. At the same time, these findings are the impulse for further research upon damage diversity in other regions as well as environmental conditions of their reasons.

#### CONCLUSIONS

1. During the analyzed period, quite dynamic growth of damage to crops due to wild boars in cereal cultivations was reported in two studied hunting circuits. A slight decrease in

the size of damages in the same period in growing maize was recorded in the forest hunting circuit (No. 137), while in the field circuit (No. 136), over 7-fold increase of damages in this type of crops, was observed.

2. Almost 4.5-fold increase of damages occurred on permanent grasslands during the evaluation in hunting circuit No. 136, while over double increase of damages due to wild animals was recorded in the forest hunting circuit No. 137. Considering the root crops, a relative stabilization of the damage during the study period was reported, and even a slight decrease in the reduced surface of damage was observed in hunting circuit No. 137.

3. Indices of attractiveness calculated for different types of crops indicate that permanent grasslands were the most preferred types in both of hunting circuits. In addition, high index of the prey preferences was found for maize cultivations within the field hunting circuit. Cereals were the least preferred by wild animals in both hunting circuits.

4. Performed analysis of the relationship between the forest fragmentation and the size of damages caused by wild animals to field crops indicate that the shape and size of forest area under current conditions of agrocoenotic structures do not play any remarkable impact on the amount of damage. This is confirmed by the facts that in the field hunting circuit characterized by a considerably large area of fragmented forests, the increase of damages during the study period was much greater than in a comparable circuit of a forest character.

5. High and statistically significant correlation coefficients between the size of wild boar population vs. the size of damages to agricultural crops indicate that the primary factor determining the dynamics of the damage increase is the population and locally high indices of wild boar population densities.

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**Streszczenie.** Celem pracy była analiza wielkości i rozkładu szkód w ciągu 6 sezonów łowieckich z uwzględnieniem łowieckiego gospodarowania populacją dzików, jak również wpływu zróżnicowania warunków środowiskowych na wielkość szkód i preferencje żerowe zwierząt w dwóch obwodach łowieckich stanowiących teren badań. Obydwa obwody łowieckie położone są w rejonie Wyżyny Lubelskiej i dzierżawione przez to samo koło łowieckie, co sprawia, że zabiegi związane z prowadzeniem gospodarki łowieckiej są zbliżone. W ocenianym okresie wystąpił dynamiczny wzrost szkód w uprawach roślin zbożowych i kukurydzy, a także w trwałych użytkach zielonych. Z kolei w uprawach roślin okopowych występowała względna stabilizacja wielkości szkód. Obliczone wskaźniki preferencji żerowych zwierząt pokazują, iż najbardziej atrakcyjnymi uprawami były trwałe użytki zielone oraz uprawy kukurydzy, zaś najmniejszą atrakcyjnością żerową cieszyły się uprawy roślin zbożowych. Analiza zależności pomiędzy wielkością i kształtem kompleksów leśnych wykazała, iż stopień rozdrobnienia kompleksów leśnych w obecnych uwarunkowaniach środowiskowych agrocenoz nie ma większego wpływu na wielkość szkód. Z kolei obliczone zależności pomiędzy liczebnością dzików i wielkością szkód w uprawach polowych wskazują, iż istnieje wysoka a zarazem statystycznie istotna zależność pomiędzy wzrostem liczebności dzików i wzrostem szkód w uprawach rolniczych.

**Słowa kluczowe:** szkoda łowiecka, uprawy rolnicze, preferencje żerowe, dzik