The telemetric tracking of wild boar as a tool for field crops damage limitation

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ABSTRACT

The article presents the possibilities of visual and statistical outputs from the telemetric tracking of game: activity data, heat map, home regions, movement routes and the points of occurrence. Nowadays the methods of the telemetric tracking of game are also used for finding the best ways to eliminate damage caused by wild boar generally, and field crops damage specifically. From telemetrically gained data it is possible to study the local habits of wild boar and their preference of crops and cultivars in various periods. On the basis of this knowledge it is possible to implement the necessary agrotechnical measures. The pilot processing and verification is run on the portal Zvěř (game) online (http://zver.agris.cz/). Currently there are 11 wild boars marked and tracked. The public part of portal is used for the basic presentation of data; in the non-public part the data of private subjects (agricultural companies and hunting organizations) that are not interested in public presentation are processed in the same way. In this way there is at disposal an integral system of wild boar tracking: capturing, marking, data collection, processing and presentation. This system can be used by research institutions, farmers and hunters.

Keywords: *Sus scrofa*; GPS; maps; visualization; maize (*Zea mays*); rape (*Brasica napus*)

Populations of wild boar prosper very well even in regions highly affected by human activity (Geisser and Burgin 1998). Even though wild boars are omnivorous animals plants are their main food (Schley and Roper 2003). Localities with high quality food resources are intensively exploited by the omnivorous wild boar, which often leads to conflicts with agricultural economy (Gerard et al. 1991, Herre 1993). High occurrence of wild boars does not result in generally enormous material damage in agriculture (Thurfjell et al. 2009) only. It can also negatively influence epidemiological situation through transmission of diseases to domestic and farm animals, as well as to humans. Damages caused by wild boars on field crops are reported in numerous studies (Groot Bruinderink et al. 1994, Baubet et al. 2003, Schley and Roper 2003, Herreo et al. 2006). This problem goes back long into history, yet it has become significant only after the population of wild boars started to grow rapidly in the whole Europe during the last 30 years.

The steep growth of wild boar populations in many European countries has led to many challenges related to the effects this may have on the landscape and socioeconomic costs. Wild boar is spread over most of Europe with the exception of northern regions (Červený et al. 2004, Ježek et al. 2011); recently it has also started to spread rapidly across Fennoscandia (Massei and Genov 2004). Its occurrence has been growing over the whole area (e.g., Scandinavia: Erkinaro et al. 1982, Germany: Feichtner 1998, the Czech Republic: Hladíková et al. 2006). The occurrence of wild boar is usually

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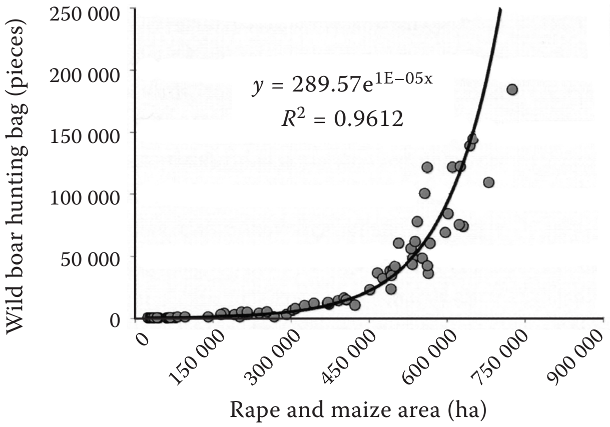

Figure 1. Dependence of wild boar hunting bag on the area of rape and maize (Hruška 2013)

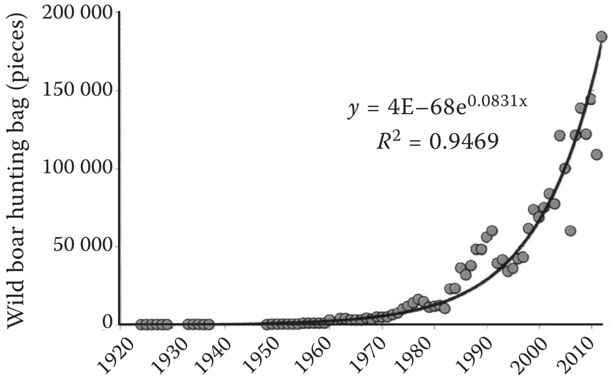

Figure 2. Trends in wild boar hunting bag in the Czech Republic 1920–2012 (Hruška 2013)

assessed through hunting statistics. The relatively largest annual harvests of wild boar are reported from Germany (14 individuals/1000 ha) and the Czech Republic (12 individuals/1000 ha).

The exponential growth of wild boar depends first of all on the structure of grown crops (Figure 1). The total area of rape and maize in the Czech Republic was 725 000 hectares in 2012, which is an absolute record. The records of areas sown with individual crops for the whole republic have been kept since 1920.

The registered harvest of wild boar in 2012 was 185 381 pieces. The exponential growth of wild boar on areas sown with rape and maize is completely logical. The combination of these two crops create perfect food and shelter conditions for wild boar. In spring the rape quickly germinates and at the turn of April and May it already creates a sufficient shelter. Later on, by the end of May it creates a sufficient resource of food. In this way wild boars move smoothly from forests, where they spent winter and where they ran out of food in spring, into rape. Rape provides ideal food and shelter for wild boars till the end of July when it is harvested. Meanwhile on adjacent fields the height of maize is sufficient enough to create a good shelter for wild boars and from the end of July it usually serves as a good resource of food as well. This second period of abundance lasts until October at least. Meanwhile acorns and beech nuts start to ripen and it is time for boars to return to forests. Wild boars can only face bigger problems in such winters when there is a shortage of acorns and beech nuts and a high blanket of snow. In that case the population growth temporarily stops. In the last decades this was the case in 2006 and 2011 (Figure 2). Nevertheless these exceptions have no influence on global trends (Hruška 2013).

The question is as follows: where can the growth of wild boar numbers stop, what is the carrying capacity of environment? Unless, of course, there is a radical intervention caused by for example African plague. Tkadlec (2013) estimates the carrying capacity to be more than 300 000 pieces hunting bag a year which is about twice as much as in the present (Figure 3). His estimate is based on population dynamics according to annual hunting bag from 1949 to 2012. This assumption was made at the time when the data indicating the slowing down of the population growth have not been identified yet.

Figures presented so far represent an average for the whole republic, nevertheless the wild boars' occurrence is not even; in some areas the figures have already reached a critical level (Figure 4).

The breeding of wild boar is really variable and all-purpose models which would show how to treat this game and how to prevent damage on

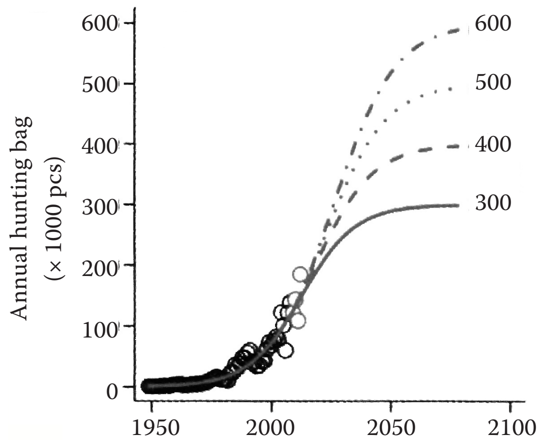

Figure 3. The logistic model of annual hunting bag with the carrying capacity of 300, 400, 500 and 600 thousand pieces hunting bag (Tkadlec 2013)

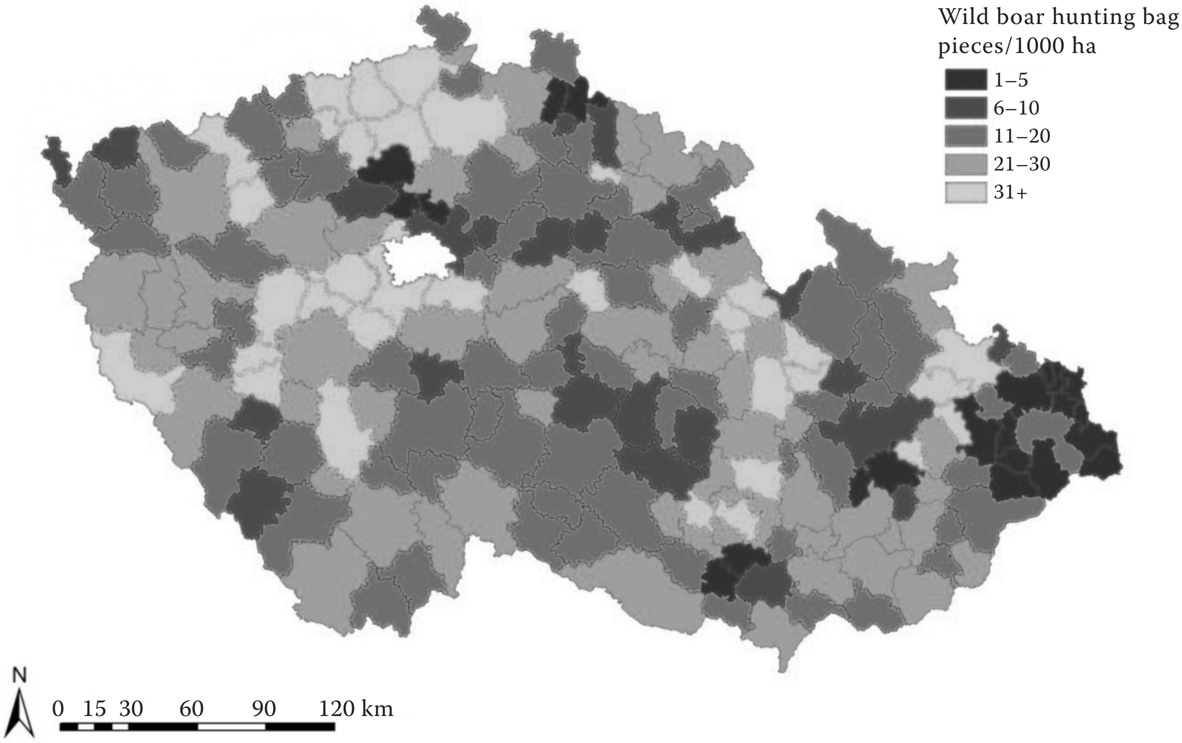

Figure 4. Wild boar hunting bag in municipalities with an enlarged sphere of activity in 2010

agricultural crops do not exist. The influence of habitats on the extent of damage in the areas with maize and other crops is connected with a variety of landscape (forests, fields), wild boars' numbers and the offer of food, e.g. the sown areas of maize, rape, other attractive crops and the abundance of oaks and beeches in forests. Even the different kind of used species can have some influence, for example the species of maize (Štípek and Ježek 2012). Therefore it is necessary to look for tools how to find out specific characteristics in local conditions and to propose an optimal solution of damage elimination. One of these options is the telemetric tracking of game with the subsequent evaluation of the collected data.

MATERIAL AND METHODS

The main task of this article is the description of several methods and tools which could help to understand the factors that may help to reduce potential conflicts between wild boars and human activity in multiple-use landscapes in Europe. This includes knowledge that may be used to develop more efficient hunting methods which could help to reduce wild boar population, to develop other mitigating actions to reduce conflicts between wild boars and human activity and to communicate basic knowledge about wild boar to various stakeholders (e.g. hunters, game keepers, land owners). To obtain the desirable data it is first of all necessary to capture the game, to immobilize it and to place GPS collars on it (Figure 5).

Animals will be caught into traps that are randomly distributed in the study area. A trap is a fenced area of 10 × 10 m, so that under ideal conditions the whole family can be trapped. The traps are equipped with a so-called sleeve enabling fixation and immobilization of animals. The adult individuals will be immobilized (confined into the fixation cage) and anaesthetized using a mixture of Telazol (3.3 mg/kg) and xylazine hydrochloride

Figure 5. A GPS collar fixed

Figure 6. Depiction in the form of points and descriptive information

(1.6 mg/kg) applied intramuscularly and equipped with a GPS collar. The immobilization will be done by specially trained workers (ordnance corps J) supervised by a veterinarian.

For the tracking GPS collars from Vectronic Aerospace GmbH, Berlin, Germany, are used. These GPS collars are equipped with GSM modules that send information on actual position to the online-user. Depending on the body size, collars of two different types are used (GPS Plus 2D or GPS Plus 3D). Owing to the quick growth of young game it is possible to mark adult specimen only. Collars contain a nucleus with a GPS and GSM module. This module enables automatic recording of the position of the marked individual with precision of about 5 m. The modules are programmable (and wireless using a UHF terminal or GSM commands, too) and offer a possibility to select time intervals of recording. Data are recorded in the memory of the collar and can be downloaded directly by the GSM module or with the help of a UHF terminal (within the distance of 2–8 km). The collar is equipped with a continually transmitting VHF sender, thus enabling the localization of marked individuals in the landscape at any time. The collar is also equipped with an activity sensor (recording every 5 min) and temperature sensor. Furthermore there is a mortality sensor which changes the frequency of the signal 24 h after the death of the marked individual. Lifetime of the battery is two years: after this time the animal has to be recaptured and the battery replaced.

Available position data gained by hoofed game tracking are continuously stored on the database server MySQL 5. Erroneously measured data are subsequently removed. The web application itself is run on the Apache web server. The basis of the application is programmed with the help of the PHP 5 (Hypertext Preprocessor) programming language using the Nette framework 2. For the visualization of movement information the topographical source materials Google Maps from the company Google Inc. are used. Communication with Google Maps is carried out with the help of Google Maps interface JavaScript API V3. The visualization on the topographical source materials makes use of JavaScript framework JQuery.

The telemetric tracking of game involves the collection, transfer, storing and processing of very large data sets. The large volume of data is mainly due to the continuous process of their collection (for a period of one to two years) combined with the frequency of measurement and data transfer (for example: GPS positions are recorded every 30 min, activity data are averaged every 5 min etc.). Another important factor is work with various output topographical source materials which are created here and presented to users.

RESULTS AND DISCUSSION

The data gained by the telemetric tracking of wild boars can be processed by several methods including their visualization in topographical source materials. These materials can be then used for the establishment of local special characteristics in the behaviour of tracked game. In this way it is possible to study local habits of wild boar, preference of crops and cultivars in different periods. And based on this knowledge it might be possible to put into practice necessary agrotechnical precautions. Pilot verification is run on Zvěř (game) portal online (http://zver.agris.cz/). Currently there are 11 wild boars marked (Jarolímek et al. 2012). These tools and methods can be used both for the needs of research and possible protection of individual agricultural companies. The users can access the pages via commonly used web browsers including mobile devices. There are five basic forms of data visualization, all of them described below.

Depiction in the form of points of occurrence. The basic depiction of the tracked specimen's position is in the form of points which show individual positions in time. With a click on individual points we can get more information, for example the time of measurement, temperature and coordinates. The positions are usually recorded by the GPS collar every 2 h (or according to the setting – this depends on the battery endurance). If the records have the required quality (first of all the accuracy resulting from the number of aimed satellites) they are stored in a database from which the necessary selections for further processing are made (Figure 6).

The selected positions are transferred from the database in a two-dimensional field for processing by JavaScript (with the use of Google Maps API). In the web application the user can specify how many positions should be shown in total. If there are more positions in the database than the chosen ones (this can be caused either by the choice of a longer period or by the selection of more individuals at the same time) the points above the chosen number are evenly left out. In concrete terms the selection of points from each x-th position is compared with the help of mathematical function modulo.

The route of movement. Furthermore it is possible to display the chosen specimen's route of movement. In this form of depiction there are connecting lines – so called Poly Lines – among the points. Poly Lines are presented with the help of Google Maps API. In the centre of these lines there are arrows indicating the direction of the

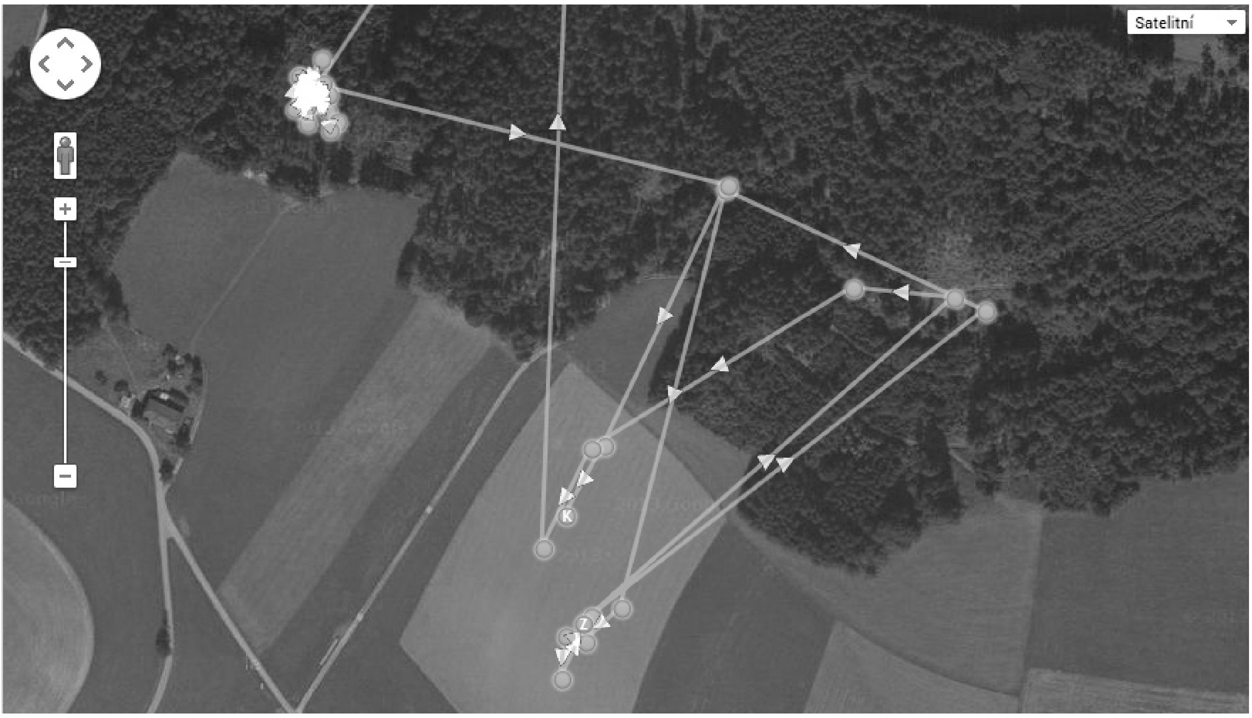

Figure 7. The depiction of the route of movement

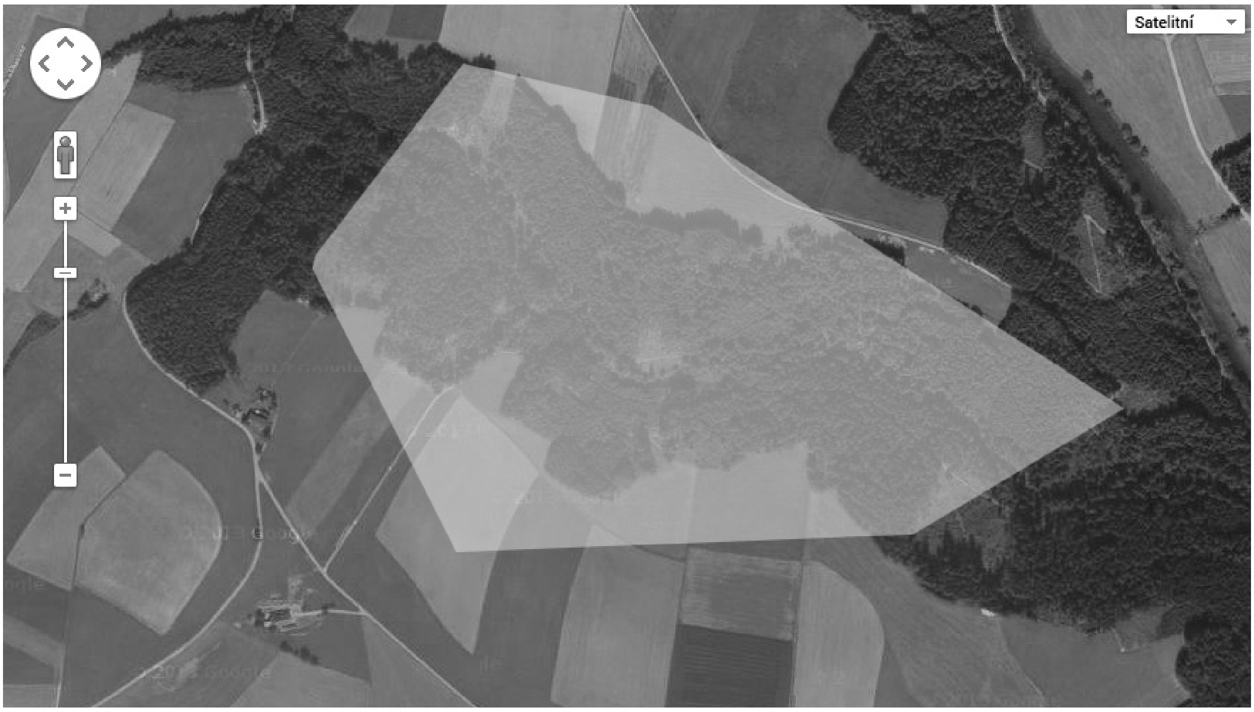

Figure 8. The depiction of a home region in the form of a polygon (Quick Hull)

specimen's movement. The point showing the beginning of the route is marked with letter Z, the point showing the end of the route is marked with letter K. The coordinates of the arrows are calculated as the medium values between adjacent coordinates. The calculated values are at disposal concurrently with the visual output (Figure 7).

The size of a home region – a polygon. To calculate and depict a home region (one of the most important parameters in the monitoring of game's movement activity) the Quick Hull algorithm was chosen (Barber et al. 1996). With its help the points marking the boundaries of MC polygon (Minimal Convex Polygon) are calculated. The area of this polygon where the specimen was moving is calculated with the help of extension Geometry for Google Maps API (Figure 8).

The density of occurrence in a home region – a heat map. The stay of a specimen in a home region (as regards the area) is not – predictably – even. For the graphic presentation of points with the different density of occurrence the heat map principle was used (Wilkinson and Friendly 2008).

The whole area of interest is divided into matrices and then points are gradually added into these matrices. The whole picture is drawn again whenever a maximum is found somewhere. At first it is drawn with the help of a monochromatic transition which is later transferred into colours. The red colour signifies the highest occurrence, the yellow a lower one and then gradually the turquoise and blue colours signify the lowest occurrence (Figure 9).

Activity data. The collars contain sensors which register the activity of game. With the help of an accelerometer the values of movements are recorded on two axes – x and y. The data are measured approximately 6–8 times a minute. In 5 minute intervals the data are averaged and the resulting value recorded. In this way huge data collections are created which are (in contrast with the previously described methods) read through the Handheld Terminal device and UHF/VHF technologies. The data are entered into the database manually. The measurement intervals for every collar can be set with the help of a service application for Ground station. The operating instructions are then sent via a mobile operator's net using short text messages.

A methodology that determines the patterns of behaviour for European deers exists. Based on the measured values the patterns of behaviour can be divided into following categories: rest, feeding, movement and quick movement. This methodology was defined by an experiment with the help of game observation in an enclosure (Löttker et al. 2009).

To define a similar methodology for wild boars it would be necessary to repeat the experiment for this group of animals but this has not been

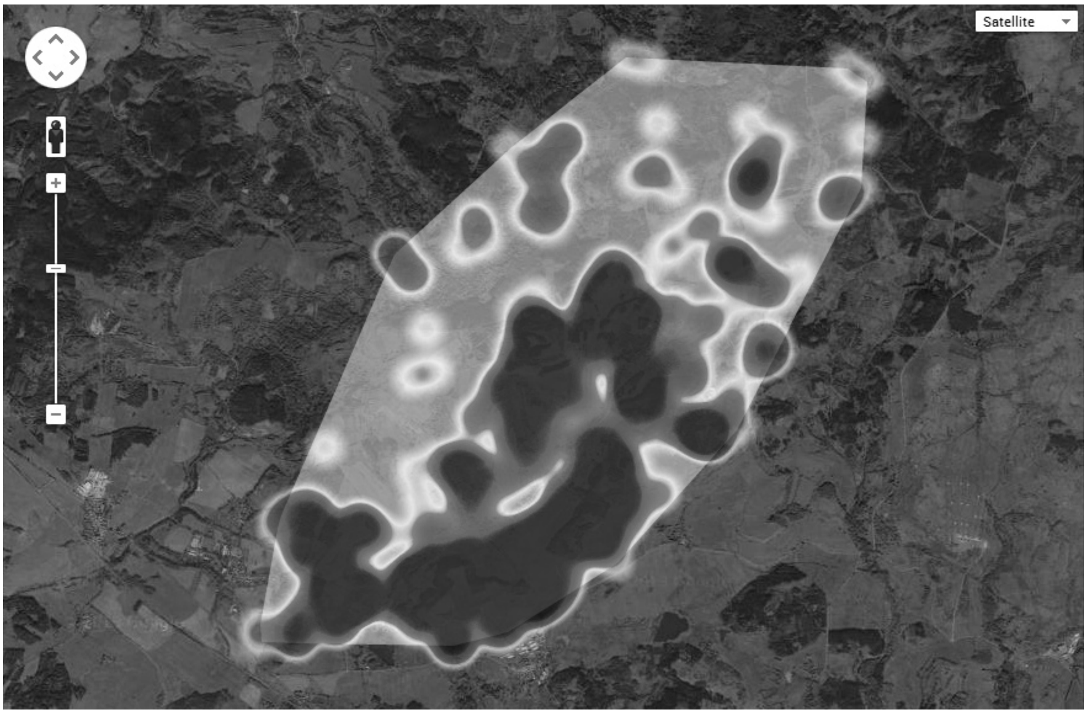

Figure 9. The depiction of a home region in the form of a heat map

arranged – according to available information – yet. Nevertheless even without this experiment it is possible – with the help of activity data from the collar – to determine if the animal is at rest (zero values) or moving.

The measured values of activity data can then be assigned to individual positions of the monitored specimen on the map. Since both types of measurement are being done at the same intervals it is always necessary to choose several activity records for every position at a certain interval (this can be set in the application).

The telemetric tracking of wild boars and the limitation of game damage on field crops. All the above described telemetric methods are implemented and can be used on the Zvěř online portal (http://zver.agris.cz/). The public part of the portal is used for the presentation of data of the Department of Game Management and Wildlife Biology of the Czech University of Life Sciences and Military Forests and Farms. Currently there are data from 11 marked wild boars and other species of game. In the non-public part of the portal the data of private subjects (agricultural companies and hunting organizations) that are not interested in public presentation are processed in the same way. In this way there is an integral system of wild boar tracking: capture, marking, data collection, processing and presentation. This system can be used by research institutions, farmers and hunters.

According to the Ministry of Agriculture of the Czech Republic nationwide damages caused by wild boar reach up to 3.5 billion CZK (in the year 2012) and the numbers of wild boar are still rising. Locally agricultural growth can be totally destroyed – especially maize (Figure 10).

The reduction of damage caused by wild boar on field crops in the present situation is possible only with the use of a complex of measurements which are primarily based on the utilization of the

Figure 10. Local damage of maize growth caused by wild boar (photo: Kamil Štípek)

knowledge about wild boar's local habits: the preference of crops and cultivars in different periods. Agrotechnical measures based on this knowledge can be combined with other options which result from the above-mentioned precautions – setting up of conditions for efficient hunting (the main task is the reduction of population) or possibly the utilization of other alternatives such as feeding of animals with the aim of luring them away or the use of repellents. When determining these procedures the telemetry becomes a significant assistant.

REFERENCES

Barber C.B., Dobkin D.P., Huhdanpaa H. (1996): The quickhull algorithm for convex hulls. Journal ACM Transactions on Mathematical Software (TOMS), *22*: 469–483.

Baubet E., Ropert-Coudert Y., Brandt S. (2003): Seasonal and annual variations in earthworm consumption by wild boar (*Sus scrofa scrofa* L.). Wildlife Research, *30*: 179–186.

Červený J., Kamler J., Kholová H., Koubek P., Martínková N. (2004): The Encyclopedia of Gamekeeping. Ottovo nakladatelství, Praha, 594. (In Czech)

Erkinaro E., Heikura E., Lindgren E., Pullianen E., Sulkava S. (1982): Occurrence and spread of the wild boar (*Sus scrofa*) in eastern Fennoscandia. Medde/anden of Societas pro Fauna et Flora Fennica, *58*: 39–47.

Feichtner B. (1998): Causes of fluctuations in the hunting kill of wild boar in the Saarland. Zeitschrift Fuer Jagdwissenschaft, *44*: 140–150.

Geisser H., Bürgin T. (1998): Das Wildschwein. Verlag Desertina, Chur.

Gérard J.F., Teillaud P., Spitz F., Mauget R., Campan R. (1991): Les ongulés sauvages de France: le sanglier. Rev Ecol (Terre et Vie) Supplément, *6*: 11–66.

Groot Bruinderink G.W.T.A., Hazebroek E., van der Voot H. (1994): Diet and condition of wild boar, *Sus scrofa scrofa*, without supplementary feeding. Journal of Zoology, *233*: 631–648.

Herre W. (1993): *Sus scrofa* Linnaeus, 1758-Wildschwein. In: Niethammer J., Krapp F. (eds.): Handbuch der Säugetiere Europas, Bd. 2/II Paarhufer-Artiodactyla (Suidae, Cervidae, Bovidae). AULA-Verlag, Wiesbaden, 36–66.

Herreo J., Garcia Serano A., Couto S., Ortuno V.M., Garcia-Gonzalez R. (2006): Diet of wild boar *Sus scrofa* L. and crop damage in an intensive agroecosystem. European Journal of Wildlife Research, *52*: 245–250.

Hladíková B., Zbořil J., Tkadlec E. (2006): The population dynamics of wild boar in central Moravia the population dynamics of wild boar (*Sus scrofa*) in central Moravia. Lynx, *39*: 55–62. (In Czech)

Hruška J. (2013): And there will be even more of them. Svět myslivosti, *9*: 7. (In Czech)

Jarolímek J., Masner J., Ulman M., Dvořák S. (2012): Cloven-hoofed animals spatial activity evaluation methods in Doupov Mountains in the Czech Republic. AGRIS on-line Papers in Economics and Informatics, *IV*: 41–48.

Ježek M., Štípek K., Kušta T., Červený J., Vícha J. (2011): Reproductive and morphometric characteristics of wild boar (*Sus scrofa*) in the Czech Republic. Journal of Forest Science, *57*: 285–292.

Löttker P., Rummel A., Traube M., Stache A., Šustr P., Müller J., Heurich M. (2009): New possibilities of observing animal behaviour from a distance using activity sensors in Gps-collars: An attempt to calibrate remotely collected activity data with direct behavioural observations in red deer *Cervus elaphus*. Wildlife Biology, *15*: 425–434.

Massei G., Genov P.V. (2004): The environmental impact of wild boar. Galemys, *16*: 135–145.

Schley L., Roper T.J. (2003): Diet of wild boar *Sus scrofa* in Western Europe, with particular reference to consumption of agricultural crops. Mammal Review, *33*: 43–56.

Štípek K., Ježek M. (2012): The influence of maize and winter wheat varieties on wild boar's choice of food. In: Proceedings of the Japanase sika deer conference, 30–32. (In Czech)

Thurfjell H., Ball J.P., Åhlén P.-A., Kornacher P., Dettki H., Sjöberg K. (2009): Habitat use and spatial patterns of wild boar *Sus scrofa* (L.): Agricultural fields and edges. European Journal of Wildlife Research, *55*: 517–523.

Tkadlec E. (2013): The carrying capacity of Czech wild boar population is unforeseeable for the time being. Svět myslivosti, *9*: 10–11. (In Czech)

Wilkinson L., Friendly M. (2008): The History of the Cluster Heat Map. The American Statistician, Alexandria.

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