WILD BOAR *(Sus scrofa)* POPULATIONS IN EUROPE

A scientific review of population trends and implications for management

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Preface

This report is based on 550 peer-reviewed scientific papers containing the words 'wild boar' and 'Europe' in their abstracts. The research papers are published in the period 1977-2017 and cover a wide range of topics. The systematic growth in the number of scientific publications on wild boar is an indication of growing environmental and social concerns about the species, which is in turn a reflection of their increasing presence across Europe.

The research shows that wild boar populations are increasing in most areas of Europe. For some, a growing wild boar population is a positive development, indicating better habitat conditions and the presence of an additional huntable species. Others are strongly opposed to an expanding population and cite the increasing negative impacts such as agricultural damage and road accidents.

The growing populations can be explained by a multitude of variables including climate change, agricultural practices, and increasing human pressures in rural areas (leisure activities, agriculture, ...).

While many research papers are trying to explain the reasons for growing populations, and their associated problems, it is hard to find scientific information on possible solutions.

This report tries to identify elements which could help manage and limit the negative impacts of the growing wild boar populations. At the same time, it calls for a stronger scientific support of existing and future management practices.

Recommendations given in this report should not be considered as solutions but should be seen as a basis for discussions in order to reconcile nature, social and economic arguments.

Janez POTOČNIK
Former European Commissioner - DG Environment

Contents

Introduction

Wild boar populations have undergone a systematic increase, in both size and distribution range, across most parts of Europe over the past 30 years. The growing number of wild boars has resulted in numerous economic, environmental, and social problems.

Hunters, landowners and environmentalists have diverging opinions on the causes of the population growth in Europe, as well as different responses to managing it.

Private landowners aim to combine biodiversity objectives with economic activities. However, the damage to agricultural land and forests in recent years due to increased wild boar populations is challenging their combined environmental, social and economic business models.

To get a better view on the current situation, the causes and effects of these growing populations, and as well as assessing the effectiveness of certain measures which are taken to mitigate negative human-wild boar interactions, we have decided to try to find some answers within the vast amount of scientific papers written on the subject.

This report is not a research paper. It is a review of the vast amount of scientific research which exists on the species. Our study is based on peer-reviewed papers published over the past 30 years on the topic of wild boar in Europe and covers a large number of research disciplines.

Basing our conclusions on existing knowledge, this study proposes a number of policy recommendations to decrease the number of negative human-wild boar interactions.

Dr. Jurgen Tack
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A review of the scientific literature on wild boar in Europe

Across Europe, wild boar populations have been growing systematically. An increase in the 1960s-1970s was followed by a period of stabilisation in the 1980s. However, recent evidence suggests that numbers of wild boar have been increasing more rapidly since the 1990s (Massei et al., 2014).

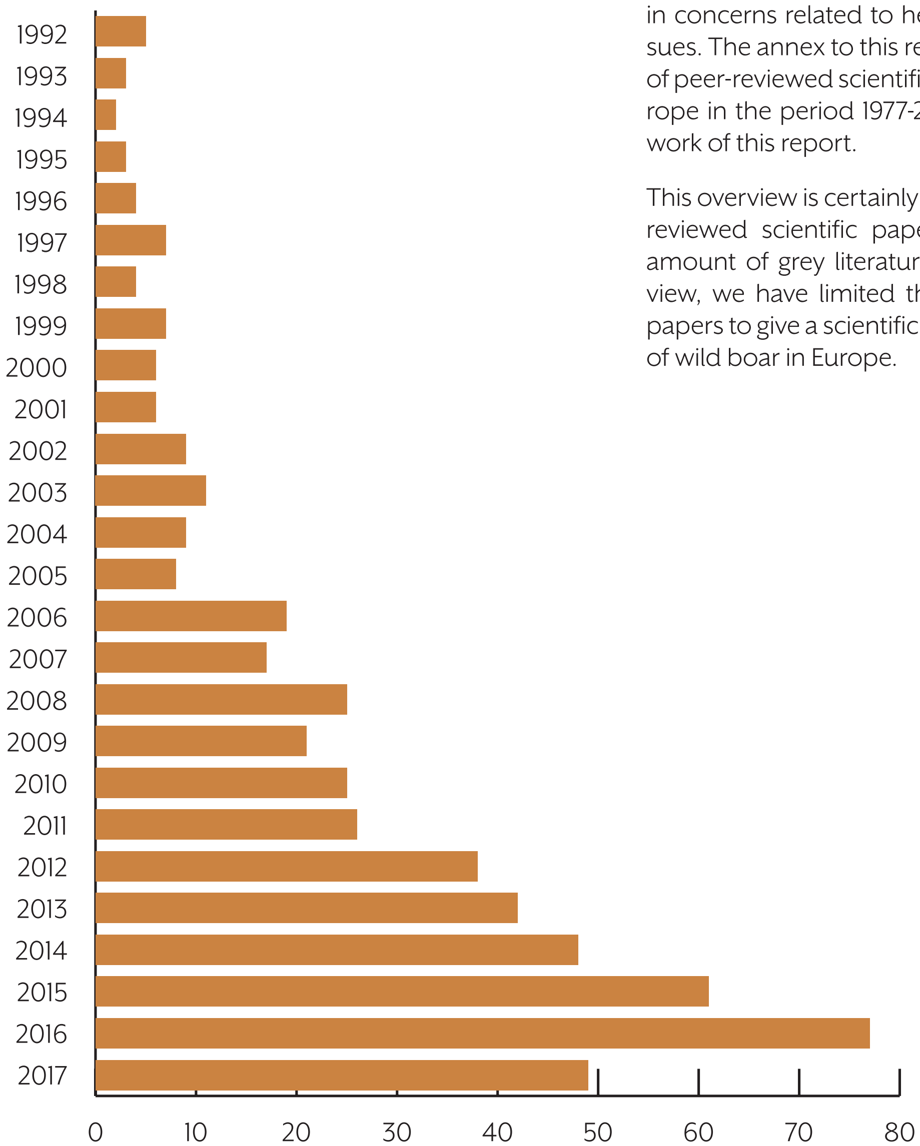

Figure 1: the number of peer-reviewed scientific papers per year in the period 1991-2017 on wild boar in Europe (Web of science – topic: wild boar Europe); 2017 up to August

In the last 30 years the scientific literature on wild boar has been increasing in parallel. This reflects both the phenomena of fast-growing populations of wild boar in Europe, and the increased concern for the potential economic, environmental and health-related impact this poses.

Numerous scientific disciplines have studied the wild boar in Europe, however there is a clear interest in concerns related to health and environmental issues. The annex to this report contains the abstracts of peer-reviewed scientific papers on wild boar in Europe in the period 1977-2017 screened in the framework of this report.

This overview is certainly not complete. Besides peer reviewed scientific papers there is an enormous amount of grey literature on the topic. For this review, we have limited the scope to peer-reviewed papers to give a scientific view on the actual situation of wild boar in Europe.

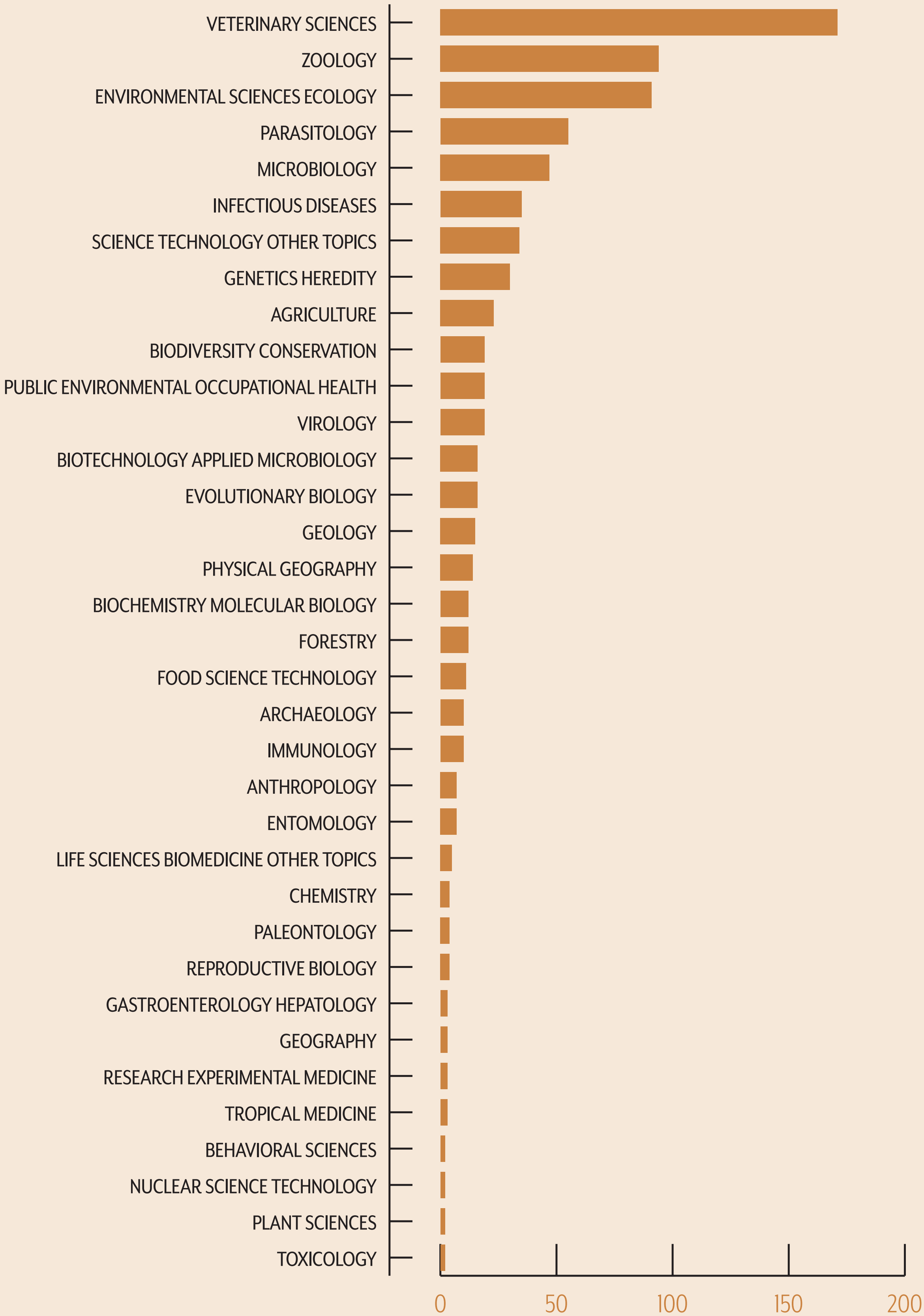

Figure 2: the number of peer-reviewed scientific papers per research area in the period 1991-2016 on wild boar in Europe (Web of science – topic: wild boar Europe)

Ecology of the wild boar

Distribution

The wild boar (Sus scrofa) is among the most widely distributed large mammals in the world (Oliver et al., 1993). The species originated in Southeast Asia during the Early Pleistocene (Chen et al., 2007) and its natural range extends from Western Europe and the Mediterranean basin to Eastern Russia, Japan and South-east Asia (Sjarmidi & Gerard, 1988).

Its distribution continues to increase worldwide. The species is extremely adaptable, with an enormous reproductive capacity, and can be found throughout a large spectrum of habitat types, ranging from semi-arid environments to marshes, forests and alpine grasslands (Sjarmidi & Gerard, 1988). One of the reasons for the wider spread of boar populations has been for their meat; wild boar farms have been established in countries where the species had long ago been hunted to extinction. The wild boar population was non-existent in Sweden ten years ago, but now an estimated 150,000 individuals are present the country (Magnusson, 2010). The UK also has a boar population for the first time in 300 years (Rozycka et al., 2015).

Due to its extensive distribution, high numbers and considerable adaptability, the IUCN has classified it as a species of least concern and it is considered an invasive species in certain areas where it has been introduced (Bieber & Ruf, 2005; Lowe et al., 2004). The species has developed several subspecies. Wozencraft (2005) describes 16 subspecies, divided in four regional groups (Western, Indian, Eastern, and Indonesian).

Social behaviour

Wild boars are social animals typically living in female dominated herds, or sounders. The sounder is led by an older female, or matriarch, and consists of interrelated females and their young, of both sexes. Male boar leave their sounder at the age of 8–15 months. Females remain with their mothers or establish new territories nearby. Adult males tend to be solitary outside the breeding season with subadult males sometimes living in small groups (Marsan & Mattioli, 2013).

Reproductivity

Wild boars show the highest reproductive rates among ungulates among all ungulate species in relation to body-mass (Lemel, 1999, Geisser & Reyer, 2005, Bieber & Ruf, 2005; Holland et al., 2009).

We here describe a traditional life cycle of the wild boar populations in Europe. The wild boar is a seasonal breeder. Later in this report we will show that this life cycle has been disturbed by a changing climate.

Rut

Sexual activity and testosterone production are triggered by decreasing day length and reach a peak in October and November when the rut occurs. In the breeding season, male wild boars, who normally live solitarily or in loosely knit groups with other males, move into female groups. Males sometimes travel long distances in search of a sounder of sows. During this period, males often refuse food and can lose up to 25% of their body weight. When several male boars show an interest in the same sow they fight potential rivals (Heptner et al., 1988). The most dominant male (quite often the largest) mate most frequently.

Gestation

European wild boar sows are normally in oestrus with a 21-day cycle from autumn until mid-summer. The start of autumn oestrus is linked to food availability and day length. The availability of food is important for the breeding success. Steroidal pheromones excreted by the male boar triggers the receptivity in sows.

Sows reach puberty from between the ages of 8 and 24 months depending on environmental and nutritional factors. The gestation period varies between 114 and 130 days for first time breeders and between 113 and 140 days in older sows.

Farrowing

Giving birth occurs mostly between March and May peaking in April. Pregnancy lasts more or less 115 days. A couple of days before giving birth the sow will leave the group and build a specially constructed nest where the piglets are born. A farrowing nest is built from standing vegetation harvested in the immediate vicinity. Parturition (actually giving birth) lasts between 2-3 hours. The average litter consists typically of 4–6 piglets, with the maximum being 10-12 (Heptner et al., 1988). Sow and piglets remain in, or close to the nest for about 4-6 days after which sow rejoin the group.

Should the mother die prematurely, the piglets are adopted by the other sows in the sounder (Marsan & Mattioli, 2013). Newborn piglets weigh around 600-1,000 grams.

Species description

NAME:

While the species is called wild boar, 'boar' is often used specifically for male specimens. Females are called 'sow' while the young are called 'piglets'. According to their age class different names are given the boars: Squeaker (0-10 months), juvenile (10-12 months), pig of the sounder (2 years), boar of the 4th, 5th and 6th year (3-5 years), old boar (6 years), great old boar (> 6 years).

Latin name: Sus scrofa

BODY:

- Massively built
- Short and relatively thin legs
- Short and massive trunk
- Comparatively underdeveloped hindquarters
- Region behind the shoulder blades rises into a hump.

NECK: Very short and thick, almost immobile.

HEAD:

- Takes up to one third of the body's entire length (Heptner et al., 1988)
- Well adapted for digging: head acts as a plow, while powerful neck muscles allow the animal to upturn considerable amounts of soil (Marsan & Mattioli, 2013): digs 8–10 cm into frozen ground and upturns rocks weighing 40–50 kg (Baskin & Danell, 2003).

EYES: Small and deep-set

EARS: Long and broad

TEETH:

- Well-developed canine teeth
- Protrude from the mouths of adult males
- Canine teeth much more prominent in males
- Grow throughout life
- Upper canines relatively short and grow sideways early in life (gradually curve upwards).
- Lower canines much sharper and longer, with exposed parts measuring up to 10–12 cm in length.

HOOVES:

- Middle hooves larger and more elongated than lateral ones, enabling rapid movement (Heptner et al., 1988)

SEXUAL DIMORPHISM:

- Very pronounced
- Males typically 5–10% larger and 20–30% heavier than females.
- Males sport a mane running down the back (particularly apparent during autumn and winter) (Marsan & Mattioli, 2013)
- During the breeding season males develop a coating of subcutaneous tissue (2–3 cm thick), extending from shoulder blades to the rump (protecting vital organs during fights).

Species description

SIZE AND WEIGHT:

- Adult size and weight largely determined by environmental factors

Western and Central Europe:

Males:
Weight: 75–100 kg
Height: 75–80 cm in shoulder height and 150 cm in body length
Largest males weigh up to 200 kg

Females
Weight: 60–80 kg
Height: 70 cm in shoulder height and 140 cm in body length
Largest females weigh up to 120 kg

In Europe's Mediterranean regions:

Males: Weight: 50 kg
Females: Weight: 45 kg
Height: 63–65 cm in shoulder heights of 63–65 cm

Eastern Europe

Males:
Weight: 110–130 kg
Height: 95 cm in shoulder height and 160 cm in body length
Large males can reach 270 kg, measuring 110–118 cm in shoulder height

Females Weight: 95 kg
Height: 85–90 cm in shoulder height and 145 cm in body length.

COAT

- Winter coat consists of long, coarse bristles underlain with short brown downy fur
- Length of these bristles varies along the body (shortest around the face and limbs, longest along the back)
- Back bristles form the mane prominent in males
- Back bristles stand erect when animal is agitated
- Color highly variable
- Color varies with age: piglets having light brown fur with pale bands extending from the flanks and back (Heptner et al., 1988)

SOUND:

- Several sounds depending on the situation: a difference is made between contact calls, alarm calls, and combat calls (Cabanau, 2001)

SMELL:

- Well-developed sense of smell (Cabanau, 2001)

HEARING:

- Acute

EYESIGHT:

- Weak (Heptner et al., 1988)
- Lacking colour vision (Cabanau, 2001)
- Unable to recognise a standing human 10–15 metres away (Baskin & Danell, 2003)

SPEED:

- Maximum speed of 40 km/h
- Jumps up to a height of 140–150 cm (Baskin & Danell, 2003)

Suckling

Piglets compete over the most milk-rich nipples. The best fed young grow faster and have stronger constitutions (Heptner et al., 1988). Piglets will cross suckle between other lactating sows. Although the lactation period lasts 2.5–3.5 months, the piglets begin displaying adult feeding behaviours at the age of 2–3 weeks.

Weaning

Rooting behaviour develops in piglets almost immediately. Piglets are fully weaned after 4 months. They will begin to eat solid foods such as worms and grubs after about 2-3 weeks.

Summer infertility

From mid-summer to the autumn sows become anoestrus.

Sows attain sexual maturity at the age of one year with oestrus first occurring after 2 years of age. Males attain it a year later but only begin participating in the rut after 4–5 years, as they are not permitted to mate by the older males (Heptner et al., 1988).
The maximum lifespan in the wild is 10–14 years, though few specimens survive past 4–5 years (Marsan & Mattioli, 2013). Boars in captivity have been known to live for 20 years (Baskin & Danell, 2003).

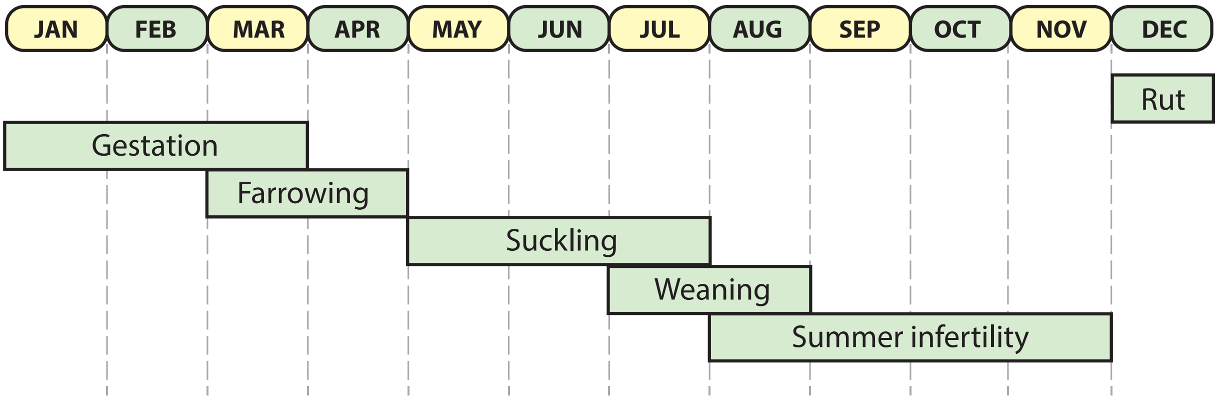

Figure 3: Reproductive life cycle of an adult wild boar sow

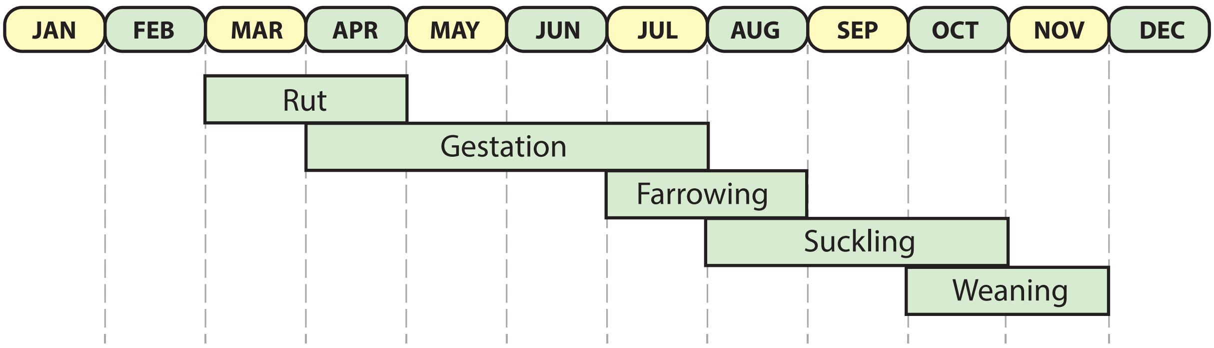

Figure 4: Reproductive life cycle of a year-old wild boar sow breeding for the first time

Mortality

Main causes of natural mortality include diseases (Rossi et al., 2011), starvation due to extreme weather conditions (Okarma et al., 1995; Massei et al., 1997) and predation by wolves (Jedrzejewski et al., 1992; Nores et al., 2008).

However, the number of wild boars killed by wolves is relatively small compared with those killed by hunters (Melis, 2006). As the wild boar has few other natural predators in the animal kingdom, by far the greatest contributor to wild boar mortality is man (primarily through hunting or car accidents) (Keuling et al., 2013; Toïgo et al., 2008; Gamelon et al., 2011, Šprem et al., 2013; Morelle et al., 2013; Prevot & Licoppe, 2013).

Habitat

The wild boar inhabits a diverse array of habitats (Heptner et al., 1988), ranging from semi-arid environments to marshes, forests and alpine grasslands (Sjarmidi & Gerard, 1988). In order to survive in a given area, wild boars require a habitat fulfilling three conditions:

- Areas of heavy brush, providing shelter from predators
- Water for drinking and bathing purposes
- Absence of regular snowfall (Marsan & Mattioli, 2013)

The main habitats favoured by boars in Europe are deciduous and mixed forests, preferably forests composed of oak and beech enclosing marshes and meadows.

Wild boar rest in shelters made from spruce branches and dry hay. These resting places are occupied by whole families (though males lie separately). They are often located in the vicinity of streams, in swamp forests, in tall grass or shrub thickets.

Suitable habitats should provide highly diverse and abundant food sources to the wild boar population. Scientific research has shown the species to cause disturbance to plant and animal communities without a proven effect on overall biodiversity (see 'Damage to biodiversity').

Diet

The wild boar is a highly versatile omnivore who adapts easily to changing food availability. Seasonal, interannual and regional differences in the diet, together with its striking overall breadth, indicate that wild boar are opportunistic omnivores whose diet, in any particular instance, is largely determined by the relative availability of different food types (seasonal, geographical and human caused changes) (Schley et al., 2003).

Their food can be divided into four categories (Heptner et al., 1988):

- Rhizomes, roots, tubers and bulbs
- Nuts, berries, and seeds
- Leaves, bark, twigs, and shoots, along with garbage.
- Insects, earthworms, birds, mammals, amphibians, reptiles, gastropods, myriapods, mollusks fish and carrion.

A 50 kg (110 lb) boar needs around 4,000 – 4,500 calories of food per day. This amount increases during winter and pregnancy (Marsan & Mattioli, 2013). Should regular wild foods become scarce, boars will eat tree bark and fungi, as well as visit cultivated potato, artichoke fields, maize, rapeseed, corn and mustard (Heptner et al., 1988).

Boars may occasionally prey on small vertebrates like newborn deer fawns, leporids and galliform chicks (Marsan & Mattioli, 2013).

Predators

In Europe, wild boar piglets are vulnerable to attacks from lynx, brown bears and wolves.

The grey wolf is the main predator of wild boar throughout most of its range. A single wolf can kill around 50–80 boars in one year (Heptner et al., 1988). In Italy and Belarus' Belovezhskaya Pushcha National Park, boars are the wolf's primary prey (Marsan & Mattioli, 2013).

The population of wolves across Europe remained stable or increased in the last 30 years (Jedrzejewski et al., 1992; Linnell et al., 2001; Kaczensky et al., 2014; Jedrzejewski at al., 2000; Andersone & Ozolins, 2004; Valdmann et al., 2005; Mattiolo et al., 2011). The number of wild boars killed by wolves is relatively small compared with those killed by hunters (Melis, 2006). In Poland hunters are killing 3 to 7 times more wild boars compared with wolves (Jedrzejewski et al., 2000). In Spain 12% of the mortality of wild boar can be explained by wolves while 31% can be explained by hunting (Jedrzejewski et al., 1992).

Population densities in Europe

Monitoring

Estimating population densities is an essential part of successful wildlife management. Reliable population estimates are needed for effective management measures of this species. Unfortunately, counting boars is a difficult and imprecise science (Vetter et al., 2015). Due to their intensive reproduction, hidden way of life (Fernández-Llario, 2004), nocturnal activity (Lemel et al. 2003), migration over longer distances, and feeding behaviour, compared to other wild-living ungulates, the wild boar is a problematic species to develop accurate population estimates.

It is therefore vital to gather accurate and comprehensive data. In the past decade several alternative methods have been developed with varying degrees of success. Engeman et al. (2013) describe monitoring methods that have proven and also potential applications to wild boar management (Table 1). While several methods are currently in use, the combined use of wildlife cameras and food to actively attract wild pigs to a given location is still one of the most efficient practices.

However, to conduct meaningful, area-wide, simultaneous counts as a method to obtain estimates of minimum population size, Scheppers et al. (2015) state this would require the cooperation of all landowners/managers alike to have access to both the locations at which feeding stations can be constructed and maintained and for the simultaneous counting sessions.

Type of survey	Measurement tool(s)	Potential measurement	Potential metrics of abundance
Track	Tracking plots	Number of track intrusions Presence-absence	Index
Dung	Defined areas for Pellet counts DNA analysis	Number of pellet groups Number indivifduals and "recaptures"	Index Known to be alive M-R density estimate
Road counts (counts from vehicles)	Human observers Spotlight Night vision Thermal imaging	Counts Distance to animals observed	Index Density estimate
Aerial surveys	Human observers Video Thermal imaging	Counts Number of animals in strip transect(s) Distance to animals from aerial transect	Index Density estimate
Animal marking	Trap and mark Bait markers	Resight/recapture Capture andcheck for mark	Density estimate Known to be alive index
Take rates	Hunter survey	Hunter take Hunter effort	Take index Take/effort index
Camera	Camera traps	Number photographed Resight (recapture)	Index Known to be alive index Density estimate
Plot occupancy	Geographic units	Assessed occupancy wihin a unit	Density estimate Occupancy index

Table 1: Summary of the type of survey methods, with the means of data collection (measurement tools), the type of measurements collected (potential measurements), and the abundance measurement (potential metrics of abundance). More details of usage and analyses for each method are discussed in the text (source: Engeman et al., 2013)

Data availability

Current population estimates necessarily still rely on a number of different data inputs to approximate population numbers and population trends. Foremost among this are the traditional methods of hunting bag reports, sightings and reported road accidents involving wild boar (Massei et al., 2011).

While hunting tables and hunting bags provide the most robust data available to researchers, giving an indication of population size and density, this method nonetheless remains unreliable and patchy (Sarasa & Sarasa, 2013; Vetter et al., 2015). Not least of all due to inconsistent hunting legislation across regions: areas which have strict hunting regulations consequently provide more reliable information than those areas or countries where hunting regulations and wildlife management are lax. Poaching, illegal or undeclared hunting also skews available figures. Even where official figures are available experts declare them at best incomplete and of questionable accuracy (Martínez-Jaúregui et al., 2011, Sarasa & Sarasa, 2013)

Consequently, a study comparing wild boar populations across the 28 Member States does not exist. However, a combination of localized scientific studies, as well as local or regional hunting statistics allow us to identify trends in wild boar populations generally. Over the last 30 years, most studies discussing or mentioning wild boar abundance and densities in Western Europe have suggested that overall wild boar populations are stable or increasing.

However, there are some localized exceptions to the trend for example, the canton of Geneva, where researchers found the population to be decreasing (Hebeisen et al., 2008). Similarly, an intensive monitoring programme running in Northern Spain found there to be a non–linear decrease of 23% in the number of wild boar seen per drive hunt between 2004 and 2011 (Sarasa & Sarasa, 2013).

The gathering of good qualitative data is essential for wild boar management. At present there is more data on the population size and distribution of the elephant in Africa than on the wild boar in Europe. With increasing human-wild boar conflicts (Apollonio et al., 2010; Massei et al., 2011; Glikman & Frank, 2011; Riley et al., 2003; Carnevali et al., 2009; Brøseth & Pedersen, 2000; Servanty et al., 2011; Cleveland & Hebblewhite, 2012) it is striking that data on the population size and distribution of wild boar in Europe remains scattered and incomplete.

Population trends in Europe

Although no EU-wide study on wild boar populations exists, most researchers have shown localized increases in population from which wider trends can be extrapolated. The consensus in the hunting and conservation communities is that overall wild boar numbers have been growing steadily across Europe in the past 30 years.

A 1986 European-wide study on wild boar population trends by Sáez-Royuela & Telleria showed increases in wild boar numbers between the 1960s and the 1980s in several European countries. They detected a sharp increase in growth rate between 1965 and 1975 followed by a period of stabilisation. The increase in numbers of wild boar were explained by a combination of factors: very high reproduction rates, dispersal potential, lack of large predators, reforestation, deliberate releases for sport hunting, habitat alterations due to humans, and mild winters (Genov, 1981; Fonseca et al., 2011; Gethöffer et al., 2007; Cellina, 2008; Borowik et al., 2013; Jerina et al., 2014).

Based on the available data, this study maintains that wild boar populations are still growing in most European countries and the potential for human-wild boar conflicts are therefore further increasing (Apollonio et al., 2010; Massei et al., 2011; Glikman & Frank, 2011; Riley et al., 2003; Carnevali et al., 2009; Brøseth & Pedersen, 2000; Servanty et al., 2011; Cleveland & Hebblewhite, 2012).

Each of the following countries shows significant growth in wild boar populations in recent decades. Between brackets the increase over the time period indicated in the graph.

Austria

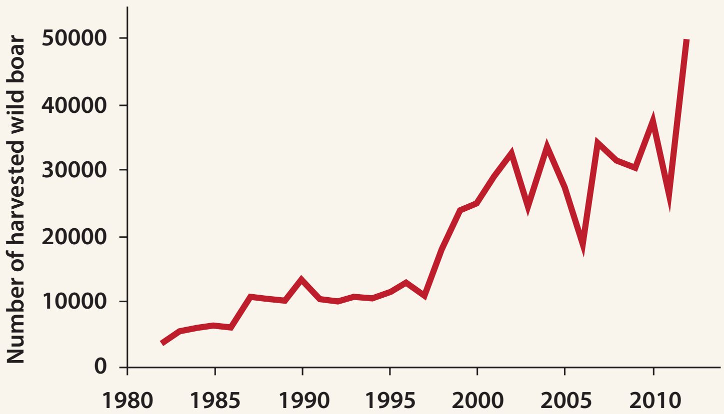

Figure 5: Wild boar hunting bags from Austria. Adapted from Massei et al. (2014)

Data source

STAT cube – statistical database of statistics, Austria (http://statcube.at/statistik.at/ext/superweb/loadDatabase.do)

Belgium

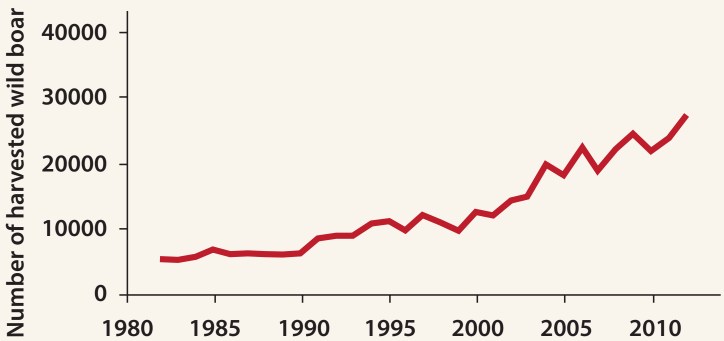

Figure 6: Wild boar hunting bags from Belgium (Wallonia). Adapted from Massei et al. (2014)

Data source

Service Public de Wallonie – Département de la Nature et des Forêts

Remarks:

Data are reported only for the southern part of the country (Wallonia). Flanders (northern part) was colonized by wild boar only since 2006. Recent newspaper clippings indicate a fast-growing population.

Croatia

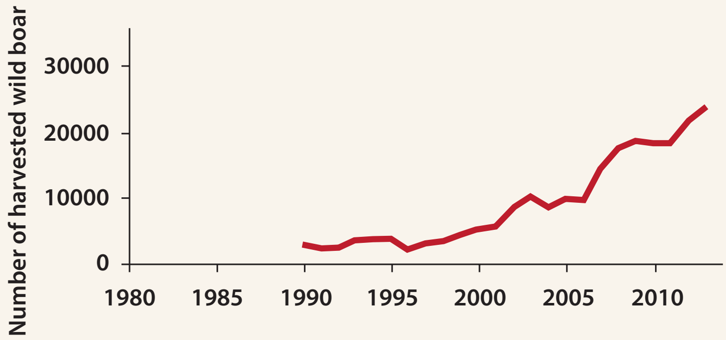

Figure 7: Wild boar hunting bags from Croatia. Adapted from Massei et al. (2014)

Data source

Ministry of Agriculture, Information System of Central Hunting Records (https://lovistarh.mps.hr/sle/login.aspx?ReturnUrl=%2fsle%2fdefault.aspx), Croatian Hunting Association.

Remarks:

data highly underestimated

Czech Republic

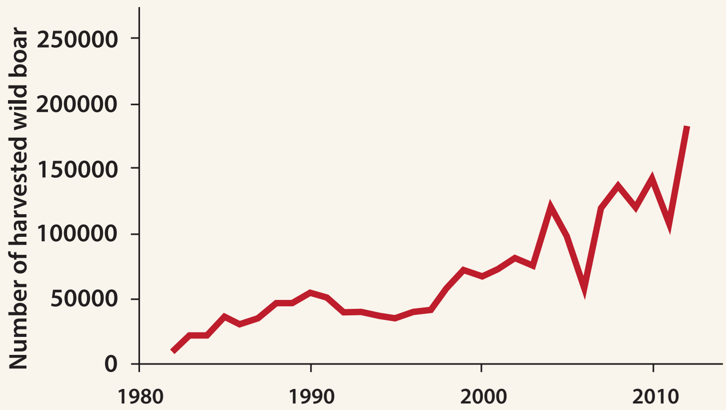

Figure 8: Wild boar hunting bags from Czech Republic. Adapted from Massei et al. (2014)

Data source

Ministry of Agriculture of the Czech Republic

Denmark

No national data available

Remarks: species has become re-established following farm escapes (Andersen & Holthe, 2010)

Estonia

No national data available

Remarks: wild boar has recently recolonized Estonia (Veeroja & Männil, 2014)

Finland

No national data available

Remarks: wild boar has recently recolonized Finland (Erkinaro et al., 1982)

France

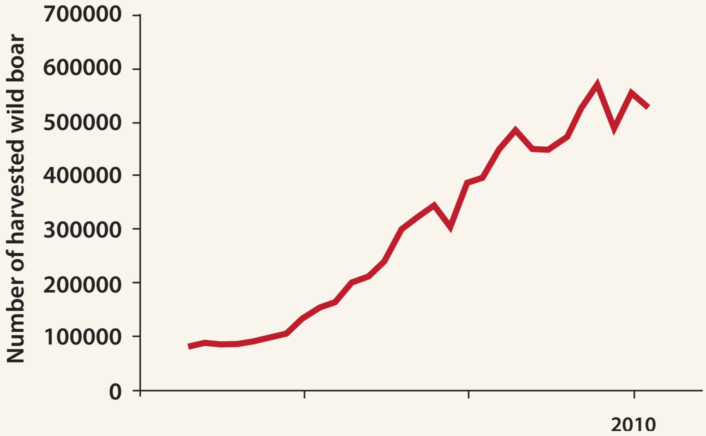

Figure 9: Wild boar hunting bags from France. Adapted from Massei et al. (2014)

Data source

Réseau Ongulés Sauvages ONCFS-FNC-FDC (Wild Ungulates Network ONCFS-FNC-FDC) (http://www. oncfs.gouv.fr/Reseau-Ongules-sauvages-ru104). ON- CFS = French National Agency for Wildlife (http:// www.oncfs.gouv.fr/Reseau-Ongules-sauvages-ru104); FNC = National Hunters Federation; FDC = Depart- mental Hunters Federation. ONCFS – Validation of hunting license (Budget Division)

Germany

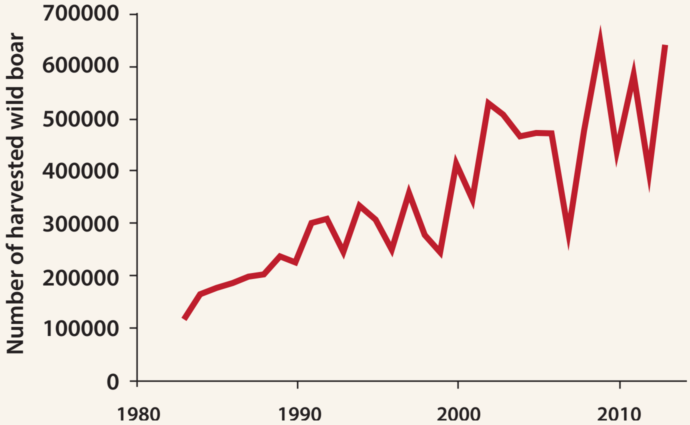

Figure 10: Wild boar hunting bags from Germany. Adapted from Massei et al. (2014)

Data source

Deutscher Jagdschutzverband (German Hunter Association) (see http://www.jagdnetz.de/datenund- fakten/jah-resstrecken?meta_id = 267 and http:// www. jagdnetz.de/datenundfakten?-meta_id=116)

Remark:

data accurate after 1989/1990 (reunifica-tion of Germany)

Hungary

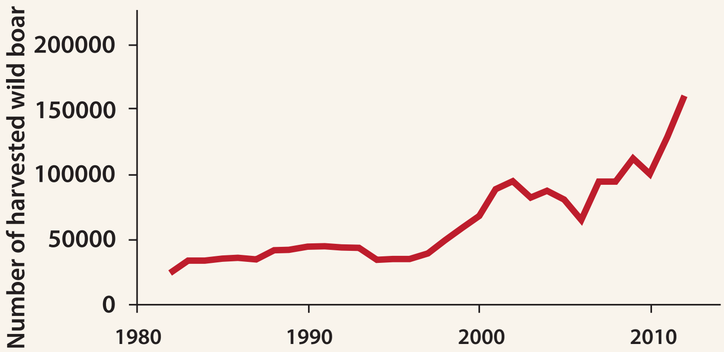

Figure 11: Wild boar hunting bags from Hungary. Adapted from Massei et al. (2014)

Data source

National Game Management Database, Gödöllö, Hungary.

Italy

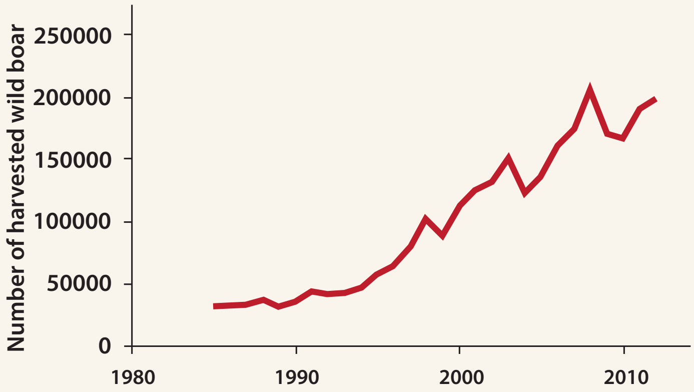

Figure 12: Wild boar hunting bags from Italy. Adapted from Massei et al. (2014)

Data source

National Ungulates Databank, ISPRA (Institute for Environmental Protection and Research) (http://www. isprambiente.gov.it/it). Italian National Institute of Statistics (http://www.istat.it)

Remarks:

- a complete dataset was available for five out of 21 regions, representing 73% of the total harvest of wild boar in Italy
- data reported are extrapolated from those five regions to the whole country taking into account the data of the other regions (methodology describes in Massei et al., 2015)
- harvest may be underestimated (National Ungulate Databank)
- total number of wild boars could be up to 300 000

Latvia

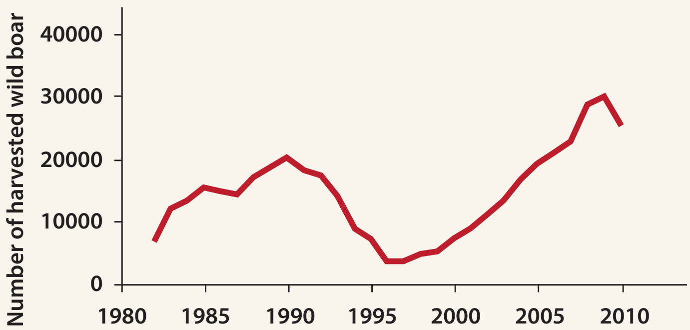

Figure 13: Wild boar hunting bags from Latvia. Adapted from Massei et al. (2014)

Data source

The State Forest Service of Latvia (SFS) (www.vmd.gov.lv)

Luxembourg

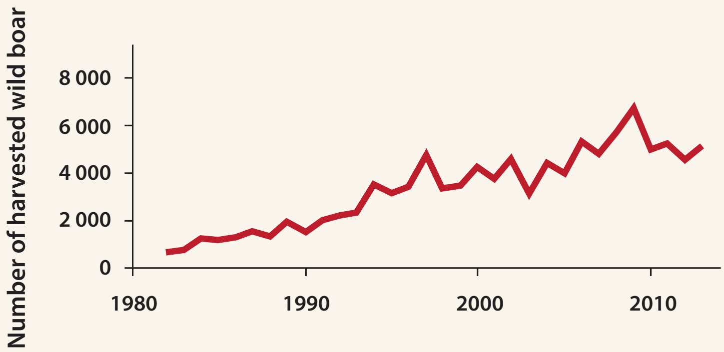

Figure 14: Wild boar hunting bags from Luxembourg. Adapted from Massei et al. (2014)

Data source

Administration de la Nature et des Forêts, Luxembourg. Ministère du Développement Durable et des Infrastructures, Département de l'Environnement, Luxembourg

Norway

No national data available

Remarks

- species was expected to recolonize Norway (Rosvold & Andersen, 2008)
- first wild boar was shot 40 km from Oslo in 2013 (http://sciencenordic.com/ wild-boars-generate-worries-)

Poland

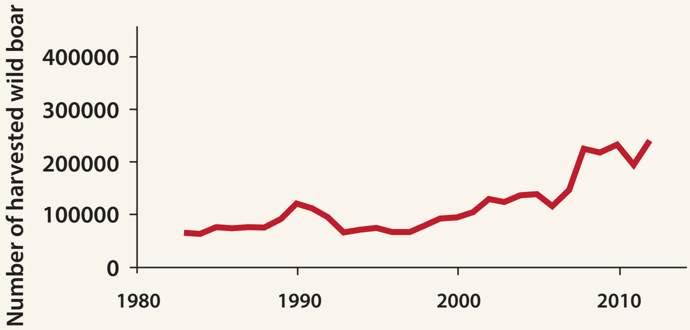

Figure 15: Wild boar hunting bags from Poland. Adapted from Massei et al. (2014)

Data source

Forestry Statistical Yearbooks (1975 – 2013), Central Statistical Office of Poland

Portugal

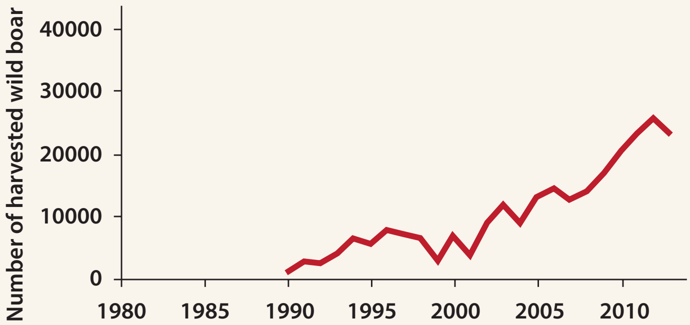

Figure 16: Wild boar hunting bags from Portugal. Adapted from Massei et al. (2014)

Data source

Portuguese Institute for Nature Conservation and Forests (www.icnf.pt). Portuguese Science Foundation (FCT) within project PEst-C/MAR/LA0017/2013

Russia

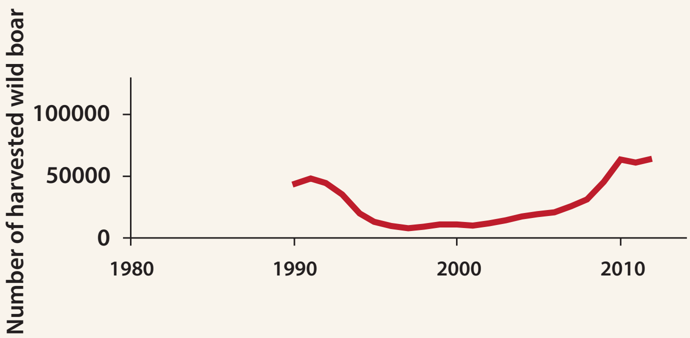

Figure 17: Wild boar hunting bags from Russia. Adapted from Massei et al. (2014)

Data source

Russian Committee for Statistics Roskomstat (www.rks.ru)

Remarks:

- data probably underestimated (Massei et al., 2015)

Serbia

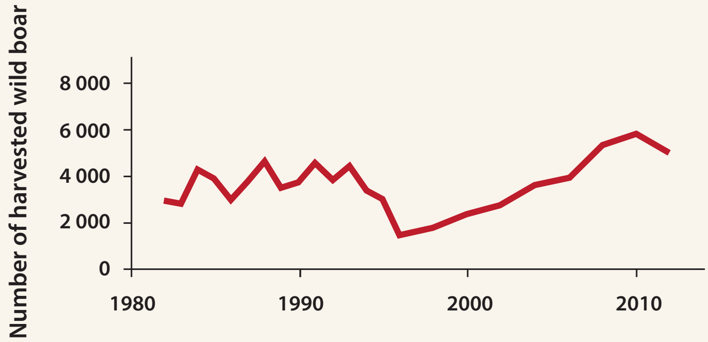

Figure 18: Wild boar hunting bags from Serbia. Adapted from Massei et al. (2014)

Data source

Statistical Office of the Republic of Serbia (www.stat. gov.rs). Hunting Association of Serbia

Remark:

- data highly underestimated

Slovenia

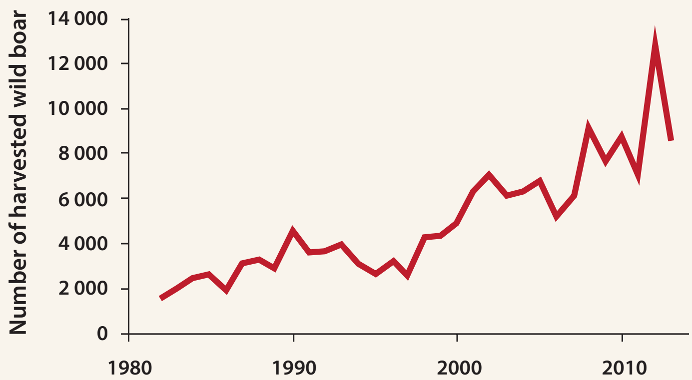

Figure 19: Wild boar hunting bags from Slovakia. Adapted from Massei et al. (2014)

Data source

Statistic Yearbooks of the Republic of Slovenia (1982- 2012), annual hunting management plans for all 15 Hunting Management Districts (2009-2013) Slovene hunting information system (2001-2013)

Spain

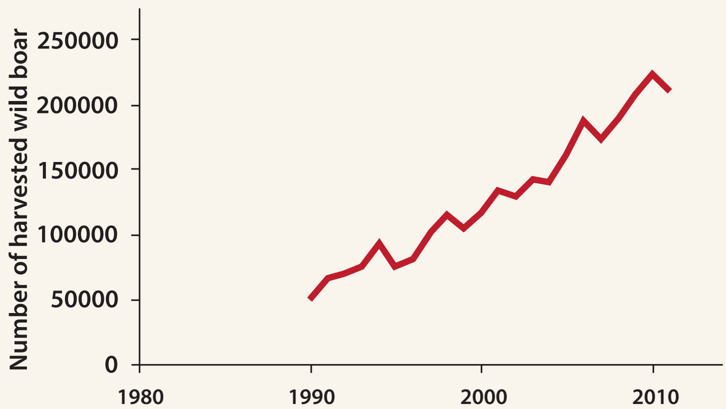

Figure 20: Wild boar hunting bags from Spain. Adapted from Massei et al. (2014)

Data source

Spanish Ministry of Agriculture, Food and Environment and Spanish Hunters Federation

Sweden

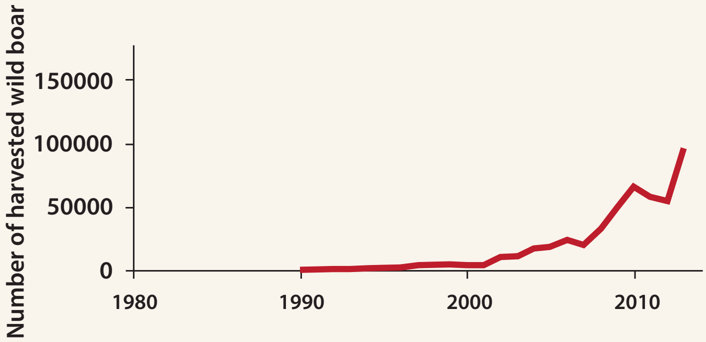

Figure 21: Wild boar hunting bags from Sweden. Adapted from Massei et al. (2014)

Data source

The Swedish Association for Hunting and Wildlife Management, Swedish Environmental Protection Agency

Remarks:

- wild boar has recently recolonized Sweden (Erkinaro et al., 1982)

Switzerland

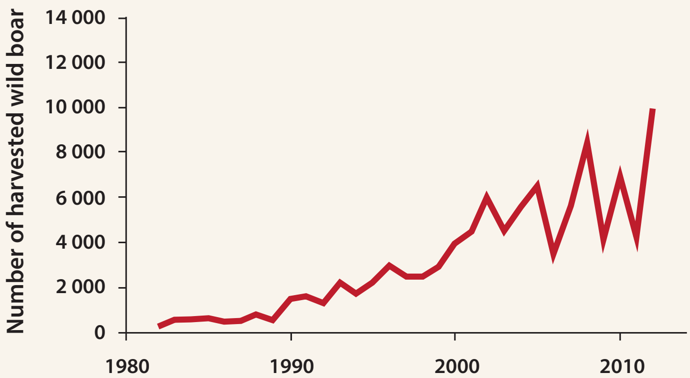

Figure 22: Wild boar hunting bags from Switzerland. Adapted from Massei et al. (2014)

Data source

Office Fédéral de l'Environnement OFEV Statistique de la Chasse

United Kingdom

No national data available

Remarks:

- **species has become re-established following farm escapes (Wilson, 2005; 2014)**

Impact of wild boar on economic interests and conservation

The evidence indicates that wild boar numbers are on the rise across Europe and have resulted in an increase in conflicts between humans and wild ungulates (Veeroja & Männil, 2014; Keuling et al., 2013; Gamelon et al., 2011; Šprem et al., 2013; Amici et al., 2012; Liberg et al., 2010; Wotschikowsky, 2010). These clashes arise for different reasons, including damage to agricultural crops and property (Schley & Roper 2003), the risk of disease transmission to humans, livestock or other domestic animals, road collisions with vehicles, and damage to forests and their regeneration

(Groot-Bruinderinck et al., 1994). Additionally, wild boar's extensive rooting for the underground parts of plants and their predation on birds may pose a threat to ecosystems (Giménez-Anaya et al. 2008), especially in parks, old growth forests, and in the Natura 2000 network of protected areas.

Due to their abundance and the implied increase in social conflicts, economic losses and a risk to natural ecosystems, the responsible management of their populations and limitations to their negative impacts will become a major challenge.

Human and animal health aspects

Wild boars are known to be responsible for the spreading of several diseases to both livestock and people (Jansen et al., 2007; Rossi et al., 2011.). During the last 30 years the number of disease notifications in wild boar in Europe has significantly increased (see table 2) Boadella et al. (2012) showing clear correlations between disease intensity and persistence and wild boar abundance.

Here we provide a brief overview of the most prevalent zoonotic and other transmissible diseases.

Diseases

Hepatitis E

Swine hepatitis E virus (HEV) is considered to be a new zoonotic agent due to its close genomic resemblance to the human HEV. The disease causes asymptomatic infection in swine; however, it is a public health concern, causing acute hepatitis in humans of varying severity. In humans, Hepatitis E is a liver disease caused by the hepatitis E virus. The virus has at least 4 different types: genotypes 1, 2, 3 and 4. Genotypes 1 and 2 have been found only in humans. Genotype 3 and 4 viruses circulate in several animals without causing any disease (including pigs, wild boars, and deer) but occasionally infect humans.

The WHO (2017) estimates that hepatitis E caused approximately 44,000 deaths worldwide in 2015 (accounting for 3.3% of the mortality due to viral hepatitis).

Classical swine fever (CSF)

Despite considerable progress in the last 20 years, swine fever, also known as hog cholera or swine plague, is still one of the main viral diseases in pigs, both in Europe and worldwide (Pejsak et al., 2014). Wild boar populations play a crucial role in the spread as the reservoir of CSF in Europe. The disease can spread quickly in wild boar, and crosses easily to domestic pigs, with occasional outbreaks continuing to be recorded in the UK, Germany, Poland, Hungary, among others. Swine fever causes fever, skin lesions, convulsions, and usually (particularly in young animals) death within 15 days. A small fraction of the infected pigs may survive and are rendered immune.

In the European Union, the combination of prophylactic mass vaccination and culling of infected pigs in endemic regions has made it possible to almost eradicate the disease, with occasional, contained, relapses. However, vaccination was banned at the end of 1990 before the internal common market was established in the EU and is allowed only in severe emergencies. In addition, there are strict restrictions on the international trade in pig products from countries using vaccination (Greiser-Wilke & Moennig, 2004)

African swine fever

The recent emergence and spread of African swine fever (ASF) in Eastern Europe is perceived as a serious risk for the pig industry in the European Union (EU). ASF has recently appeared in several European countries, with cases linked to the movement of native wild boar (Mur et al., 2014; Guinat et al., 2016b; Galindo & Alonso, 2017). ASF is devastating for the pork industry, causing massive losses of animals due primarily to enforced culling and mortality of infected animals (Guinat et al., 2016a). Further economic loss from trade restrictions can be severe (Guinat et al., 2016a).

In January 2014 Lithuania made the first notification of ASF cases in wild boar, and was followed by Poland, Latvia, and Estonia. Since late 2017 the disease is present in the Baltic countries, far-eastern Poland, Czech Republic, and in Romania, as of the beginning of 2018. Latest developments on ASF outbreak status, in both domestic pigs and in wild boar are available via the European Commission.

The disease is fatal in almost 100% of cases, it is highly transmittable and there is currently no vaccine (Galindo & Alonso, 2017). Economic consequences are serious and immediate. Herds of domestic pigs with signs of infection must be culled. A single case of ASF in a country can lead to bans on import of that countries pork products (Guinat et al., 2016a). In Estonia, 22,000 pigs were slaughtered in 2015; pork prices collapsed, and more than a third of pig farms went out of business.

The European Union has laid down prevention and control measures to be applied where African swine fever is suspected or confirmed either in holdings or in wild boars. These include both information measures and measures to prevent and eradicate the disease.

The overarching piece of legislation for the control of African swine fever is the Council Directive 2002/60/EC which lays down minimum measures to be applied within the Union for the control of African swine fever. Article 15 of Directive 2002/60/EC provides for the establishment of an infected area following the confirmation of one or more cases of African swine fever in feral pigs.

Wild boar are the primary source of spread, this has been the case in particular in both the Baltics and in Poland (Galindo & Alonso, 2017) and must play an important role in the disease's eradication. Guinat et al., (2016b) identified best practice surveillance and intervention strategies for containing ASF, among which both passive and active surveillance of wild boar populations and wild boar carcase removal in are listed as most effective. However, it is difficult to eliminate ASF from wild boar populations once it has become endemic (Gavier-Widen et al. 2015).

Disease is transmitted through faeces, urine, or nasal secretions from sick boar contaminate soil or plant material, which dog walkers or mushroom pickers, for example, might carry out of the forest. Hunters who kill an infected animal pose a bigger risk, as blood is highly infectious.

Besides wild boar transmission, there are three other major means the disease can spread: transport fomites (objects or materials which are likely to carry infection i.e. vehicles or clothing that have been in contact with an infected animal), through legal pigs, and via illegal imports (Mur et al. 2014).

A recent study (Mur et al. 2014) assessed the risk of African swine fever virus entry into the various European Union countries. The framework's results indicate that 48% of EU countries are at relatively high risk (risk score 4 or 5 out of 5) for ASF entry for at least one analysed pathway. Four of these countries obtained the maximum risk score for one pathway: Bulgaria for legally imported products during the high-risk period (HRP); Finland for wild boar; Slovenia and Sweden for legally imported pigs.

The seriousness of the threat of this disease is not being taken lightly, the Commission swiftly deployed the Community Veterinary Emergency Team (CVET) and the EU Reference Laboratory for ASF in all countries with the intent to support the veterinary authorities to apply control measures and restrictions. Experts from the OIE, as well as Russia and Belarus were invited to join the emergency team.

The CVET recommendations focused on:

- Surveillance in wild boar and domestic pigs
- Standstill and movement control
- Carcass disposal
- Swill feeding
- Biosecurity
- Awareness campaign
- Hunting practices

Some member states, such as Poland and Germany, have already amended hunting legislation in order to contain the disease.

Monitoring and surveillance of wild boar populations is crucial, quick detection increases the odds of stamping out viral incursions.

Other diseases

Foot-and-mouth disease can also take on epidemic proportions in wild boar populations. The species occasionally contracts several other zoonotic diseases such as Pasteurellosis, hemorrhagic septicemia, tularemia and anthrax. Wild boar may on occasion contract swine erysipelas through rodents or hog lice and ticks and are known to host at least 20 different parasitic worm species, with maximum infections occurring in summer. Parasites known to infect humans, include Gastrodiscoides, Trichinella spiralis, Taenia solium, and Balantidium coli. Wild boar in southern European regions are frequently infested with ticks (Dermacentor, Rhipicephalus, and Hyalomma) and hog lice.

Period	Maximum number of scientific publications
1980-84	623
1985-89	951
1990-94	1 580
1995-99	3 770
2000-04	6 390
2005-09	11 000
2010-14	15 500

Table 2: Number of disease notifications in European wild boar and confirmed spill over to animal populations including humans (after Boadella et al., 2012).

Garbage raiding

A growing number of wild boars are seen in urban and suburban environments. Cahill et al. (2012) describes wild boar related problems in 44 cities in 15 countries since 2010. Sightings are reported from Berlin, Barcelona, Rome, Vilnius and Budapest (Massei et al., 2015; Cahill et al., 2003; Jansen et al., 2007), Genoa, Milan, Toulouse, Pau, Angoulême and Trieste (ELO, 2012). The Regional Forest Office in Berlin refers to 5000 to 8000 wild boars being present in the urban area of Berlin (ELO, 2012).

Wild boars seeking food are attracted to litter, destroying litter bags in urban areas. Their increased proximity to these densely populated areas increases the scope for negative wild-boar human interactions.

Adults of both sexes living in or near urban areas can be up to 35% heavier than their forest-dwelling counterparts (Cahill et al., 2012).

Damage to agriculture

Many studies attest to the fact that, across the world, wildlife is causing damage to both livestock, (Schön, 2013; Chaminuka et al., 2012; Chhangani et al., 2008) and crops (Chhangani et al., 2008; Trdan & Vidrih, 2008; Pérez & Pacheco, 2006; Engeman et al., 2002; Wywialowski, 1996; Conover & Decker, 1991) resulting in economic losses.

In Europe, the wild boar is a major cause of damage to agricultural crops (Schley et al., 2008; Calenge et al., 2004; Schley & Roper, 2003) and the occurrence of crop damage by wild boars has increased dramatically over the past few decades (Amici et al. 2012). As a result, there has been an increase in human-wildlife conflicts, increased compensation expenditure by both private entities and governments, as well as increased risk to natural ecosystems (Amici et al., 2012).

The increasing numbers and negative impact on agricultural land is part of the reason why the wild boar is considered a pest species in many parts of the world (Schön, 2013; Bieber & Ruf, 2005). Many European countries now compensate farmers for wildlife damage. These compensations have been increasing over the years and currently tens of millions of Euro are paid out annually by governments of EU Member States in claims by farmers and land users for loss of income and damages (Mazzoni della Stella et al., 1995; Schlageter & Haag-Wackernagel, 2012).

In France compensation for crop damage caused by wild boars increased from 2.5 million Euros in 1973 to 21 million Euros in 2005, 32.5 million Euros in 2008 (Guibert, 2008; Maillard et al., 2010). In Luxembourg compensation increased from 100 000 Euros

in 1971 to 900 000 Euros in 2004 (Schley et al., 2008). In Slovenia, compensation for crop damages caused by wild boar went up from 292 000€ in 2005 to 575 000€ in 2013 (Slovenia Forest Service, 2014).

Wild boar feeds on crops such as; corn (Zea mays) (Herrero et al., 2006; Schley & Roper, 2003), potatoes (Solanum tuberosum), beans (Phaseolus spp.), peas (Pisum spp.), sugar beets (Beta spp.) (Schley & Roper 2003) and cereals (Herrero et al., 2006; Schley & Roper 2003), although the trichotomous cereals are less preferred (Schley et al., 2008).

A study into the diet of wild boar in Western Europe paid particular attention to the consumption of agricultural crops and the implications of this from the point of view of crop damage (Schley et al., 2003). The study showed that agricultural crops represent an important component of wild boar diet throughout its Western European range. Dependence on energy-rich plant material as a major component of the diet, coupled with large body size and a propensity to trample crops as well as consume them, means that wild boar cause significant agricultural damage.

In several European countries by hunting groups are required to pay the compensation to land owners and land users for damages caused by wildlife. In some EU Member States, a difference is made between hunting rights in forests and in agricultural land. As the wild boar is considered to be a forest-dwelling animal, the responsibility for payment of damages falls on those who own the hunting rights in forests. As a consequence of these policies, hunters operating in agricultural land have no incentive to control wild boar populations in these areas, which in turn may lead to growing numbers of wild boar present.

To limit the amount of compensation paid, researchers are exploring preventative methods (Schlageter & Haag-Wackernagel, 2012; Calenge et al., 2004; Geisser & Reyer 2004) to reduce the extent of damages.

Damage to biodiversity

Overabundance of one species typically has a negative impact on the overall biodiversity of a region (Kalisz, et al., 2014; Koons, D., 2014). Invasive and overabundant species are an increasing threat to biodiversity and ecosystem functioning world-wide. As such, large amounts of money are spent each year on attempts to control them.

A study undertaken by the University of Liege has shown that the evidence of damage to biodiversity by wild boar is at best inconclusive but offer different forms of wildlife management plans which can mitigate any perceived adverse impacts this species can have (Maréchal, 2005).

A similar study also taking place in a localized area of Belgium reported over-population of wild boar leading to negative impact on nesting birds while concluding that further research would be needed to ascribe any negative impact on flora present in the area.

Plants

Wild boar feed on whole plants or on vegetative parts, such as fruits, bulbs, and tubers. This way, wild boars may affect the abundance and richness of a plant species (Genov, 1981a and b; Howe et al., 1981, Singer et al., 1984). Rooting is the major cause of disturbance to plant communities (Howe and Bratton, 1976, Singer et al., 1984, Piroznikow 1998, Hone, 2002).

Assessing the impacts of wild boar on species richness is not straightforward however (Massei & Genov, 2004), show for instance in Sweden, the number of plant species increased in a wide range of habitats where wild boar rooting activity was recorded (Welander, 1995). Boar soil disturbance and foraging have been shown to facilitate invasive plants (Tierney et al., 2006; Oldfield & Evans, 2016).

The limited number of scientific papers on the relationship between wild boar and biodiversity do not show a significant relationship (either positive or negative) between wild boar presence and biodiversity. This could indicate a limited impact of wild boar on flora biodiversity. There is, however, need for additional research in this field as the relationship can differ from habitat to habitat.

Animals

Wild boar feed on a wide range of vertebrate and invertebrate species. Animal matter is found in up to 94% of the stomachs analysed, (Genov 1981b; Howe et al., 1981, Fournier-Chambrillon et al., 1995; Baubet et al., 1997). Invertebrates, such as insect larvae, earthworms, and snails are often reported as a staple food in the diet of wild boar. A study on the effects of wild ungulate density on invertebrates in Mediteranean ecosystems supports the idea that the structure of fauna communities is damaged by high density populations of wild boar (Carpio et al., 2014).

A recent study undertaken in Italy shows that the wild boar population residing within the National Park Gran Sasso e Monti della Laga has been sharply increasing and has had negative impacts on sensitive ecosystems found there (Di Nicola et al., 2015).

In continental Europe, wild boar can have a negative impact on ground-nesting birds. Predation of eggs by wild boar on ground-nesting birds is mentioned by Calderón (1977) in Spain and by Marsan et al. (1990) in northern Italy. Other small ground nesting mammals are negatively impacted by wild boar population c.f. hazel dormouse in the UK (Rozycka et al., 2015). However, data for boar densities is often not robust enough to be able to evaluate the impact of boar versus dormouse density.

Road accidents/vehicle collisions

Several authors (Keuling et al., 2013; Toïgo et al., 2008; Gamelon et al., 2011, Šprem et al., 2013; Morelle et al., 2013; Prevot & Licoppe, 2013) describe car accidents as the second most important contributor, after hunting, to wild boar mortality.

However, it seems to be extremely difficult to find exact figures for the different EU member states. In most of the countries, car accidents involving wildlife are not registered separately.

In figure 23 Häggmark et al. (2014) give an overview of car accidents with wild boar in Sweden for the period 2003-2012. The figure shows a significant increase of car accidents with wild boars. Häggmark et al. (2014) predicts total costs of car accidents with wild boar in Sweden can increase from 60 million SEK in 2011 to 135 or 340 million SEK in 2021 in present value depending on hunting pressure.

Rosell et al. (2013) describe a similar situation for Catalonia (figure 24). The sharp increase in the number of accidents involving wildlife in the period 2007-2011 (+ 41,6%) contrasts the decrease by 14,5% of accidents on the Catalan roads during the same period.

In the Netherlands, the number of car accidents involving wild boras went up from 142 in 1995 to 320 in 2003 (Van Vieren & Groot-Bruinderink, 2010). In the same period, numbers in Switzerland went up from 212 to 412. In 2005, 13 700 accidents on a total of 227 000 accidents involved deer and wild boar in Germany (Carnevali et al., 2009).

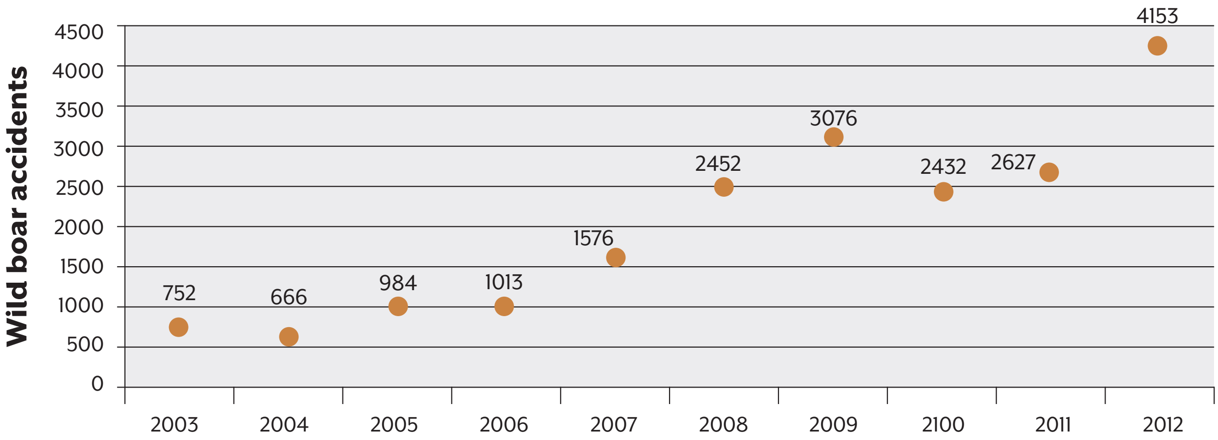

Figure 23: Traffic accidents from wild boar in Sweden over 2003-2012 Source: Nationella Viltolycksrådet (2013). Source: Häggmark et al. (2014)

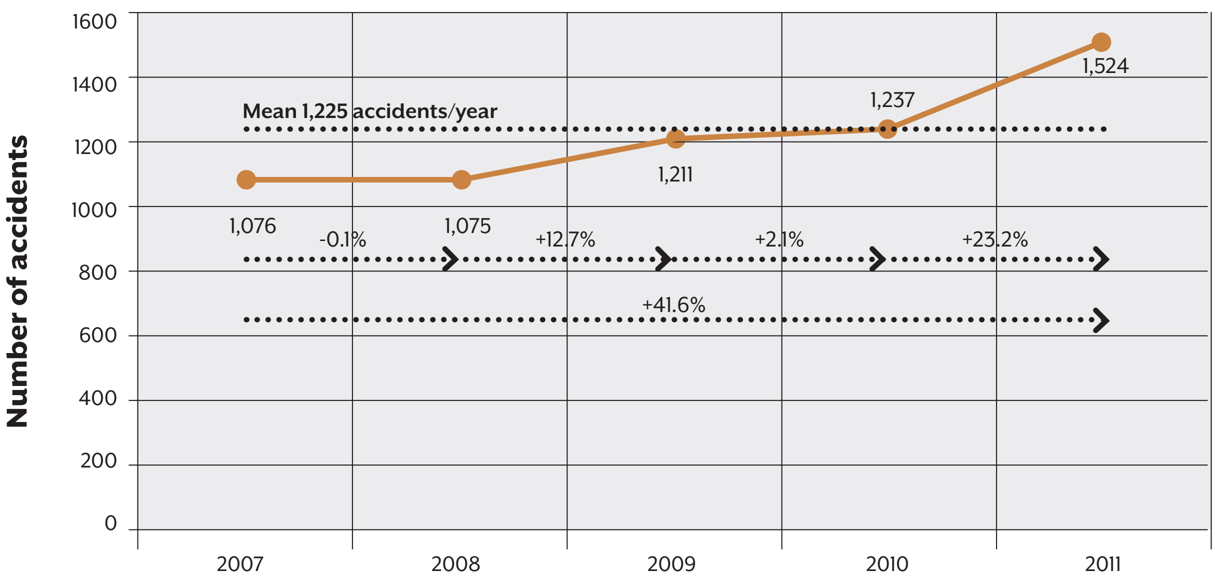

Figure 24: Evolution of the accidents involving wildlife on the interurban road network of Catalonia (source: Rosell et al., 2013)

Variables influencing population size

The body of research indicates many possible causes for the rapid increase e.g. variations in type of dominant agricultural crops; climatic changes resulting in higher temperatures, in particular milder winter temperatures and less snow cover; increased frequency of mast seeding where oak and beech are abundant; reintroduction and rapid dispersal due to human activities in areas where the species was previously absent; lack of or limited presence of predator species in many areas; and finally, a low hunting pressure (Sáez-Royuela & Tellería 1986, Jedrzejewska et al. 1997, Leaper et al. 1999, Geisser & Reyer 2005). In this sector we examine some of these variables.

Hunting

Trends in numbers of hunters

Massei et al. (2015) showed a declining or stable number of hunters in 12 out of 17 countries examined. For Luxembourg, Serbia, France, Slovenia, Portugal, Sweden, Italy and Spain the numbers were declining, for

Montenegro, Croatia, the Czech Republic and Russia numbers were stable. In Belgium, Poland, Austria, Hungary and Germany the number of hunters increases with respectively 30%, 20%, 10%, 50% and 20%. The evolution of the total number of hunters and wild boars harvested in those countries in the period 1991 and 2011 is given in figure 25.

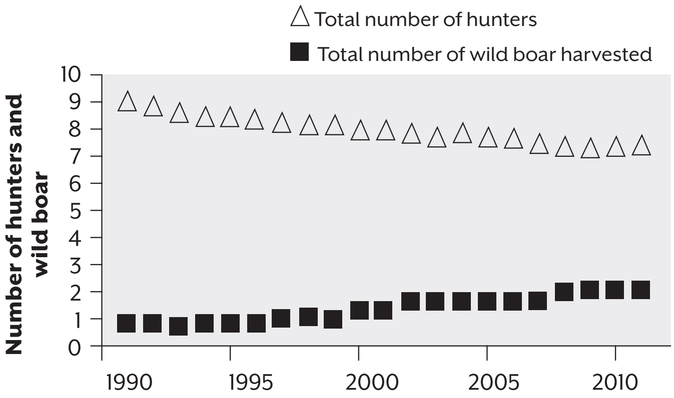

Figure 25: Total number of hunters (in millions) and wild boar harvested (in millions) in selected European countries between 1991 and 2011, when data for both variables were available for the following 16 countries: Luxembourg, Serbia, Slovenia, Belgium, Croatia, Portugal, Austria, Russia, Sweden, the Czech Republic, Hungary, Italy, Poland, France, Spain and Germany. (Source: Massei et al., 2015).

The 2015 study by Massei et al. examined the correlation between number of hunters and wild boar populations. They reviewed wild boar hunting bags and hunter population trends in 18 European countries from 1982 to 2012. Hunting bag statistics and numbers of hunters were used as indicators of animal numbers and hunting pressure. Their results confirmed that wild boar had increased throughout Europe whilst the number of hunters remained relatively stable or declined in most countries. From this correlation it is possible to conclude that current levels of recreational hunting are insufficient to limit wild boar population growth.

A new report on the contribution of recreational hunting to wild boar population control published in Springer's European Journal of Wildlife Research (Quirós-Fernández et al., 2017) cites the impact of the negative public perception of hunting which and consequent decline in the number of active hunters in Spain and the recruitment of new ones. They cite this as a factor influencing the species' population management.

Hunting practices

At present, the main regulatory mechanism for the growing wild boar populations is wildlife management plans, especially in regions where natural predators are lacking e.g. in most parts of Western and Central Europe. Hunting has been historically the single largest cause of mortality to the species (Keuling et al., 2013; Toïgo et al., 2008; Gamelon et al., 2011, Šprem et al., 2013; Morelle et al., 2013; Prevot & Licoppe, 2013). At present no European or international regulations apply to the species Sus scrofa. Directive 92/43 / EEC of May 1992, also known as the Habitats Directive, does not specifically protect boar.

Historically hunting was practiced by people living in the countryside. In the last decades, a growing number of hunters are coming from urban and suburban environments (ELO, 2013). At the same time the average age of hunters is increasing in most of the European countries (Lisjak, 2014; Massei et al., 2015). As we have seen before in this report, hunting bag figures are also increasing in parallel indicating that either hunters have increased their efforts and become more experienced in hunting wild boars, or that the number of wild boars is increasing significantly. The increasing number of road accidents with wild boars would indicate that the latter.

Hunting practices have been adapted in function of security for the hunter, animal welfare, nature conservation, a growing negative public opinion towards hunting. In many countries, hunting is strictly controlled, with limited hunting seasons, and restrictions on the shooting of young wild boars or pregnant sows. Driven hunts (battues) are limited and are portrayed negatively by animal welfare groups.

Demography

Wild boar mortality is affected differently by hunters and by predators. Hunters will kill preferably adult animals which contribute immediately to population growth while wolves will kill primarily young wild boars (Keuling et al., 2013; Jedrzejewski et al., 1992; Jedrzejewski et al., 2000; Andersone & Ozolins, 2004; Valdmann et al., 2005; Mattioli et al., 2011).

Those younger wild boars have a smaller survival rate compared with adults as they have a much larger risk of starvation (Náhlik & Sándor, 2003). Hence, the potential of hunting for regulating population growth is greater than wolves (Keuling, 2013; Genov et al., 1994; Braga et al., 2010).

Compensatory population response can be induced when the hunting pressure is high. In this case wild boar could give birth earlier resulting in young females to grow for a longer period and reaching the threshold size for giving birth earlier. Also, a larger part of the juvenile females will give birth compared with populations less under hunting pressure (Servanty et al., 2011).

Migration from neighbouring regions can significantly influence the demography (Hahn & Eisfeld, 1998).

Tranquillity

The wild boar enjoys the silence and tranquillity of the forest. The increasing human pressure on the European forests (e.g. tourism and outdoor recreation) is disturbing the wild boar in its favourite habitat. We have not been able to find scientific research showing a causal relationship between wild boar presence in agricultural land or forest and tranquillity. Additional research in this field would be welcome.

Supplementary feeding

Food provisioning by hunters, often throughout the year (Howells & Edwards-Jones, 1997) in order to bait wild boars for monitoring, easier shooting, sanitary purposes or to distract the animals from crop fields (Hahn & Eisfeld, 1998) is widespread spread throughout Europe (Cellina, 2008; Rosell et al., 2012; Servanty et al., 2009).

Supplementary feeding can reach yearly amounts of several tonnes in an area smaller than 1000 ha (Gaillard et al., 1992; Fernandez-Llario et al., 1998). The impact of such additional food is not yet clear (Geisser & Reyer, 2005). Some authors mention evidence that supplementary feeding can locally influence the population growth (Howells & Edward-Jones, 1997; Bieber & Ruf 2005, Geisser & Reyer, 2005) and increase, rather than decrease the damage to agricultural fields (Geisser & Reyer, 2004). However, the effects of feeding are unclear and further study is necessary in order to evaluate its impact on population dynamics (Lemel 1999, Náhlik & Sándor 2003, Geisser & Reyer 2004, Geisser & Reyer 2005).

An extensive study by Cellina (2008), showed there was little evidence that either the percentage of supplemental food in the stomach contents, or the density of year-round supplemental feeding sites, impacted on any aspect of wild boar morphology or reproduction. However, this study did not find evidence for the effectiveness of supplemental feeding against damage to agricultural crops.

During winter and spring supplementary feeding could potentially prevent the population from spreading as a shortage of food results in a search for new and additional food sources.

Depending on the population size of wild boar in a specific area and the damages caused by the population, local governments, landowners, farmers, hunters and environmentalists will have very different opinions about the desirability of supplemental feeding.

Climate

Several factors have been discussed as influencing factors in population trends, i.e. increased cultivation of crops and artificial feeding (Schley et al., 2008), however climate change has been posited as among the single largest contributing factors to expanding populations (Vetter et al., 2015). In this section we will provide an overview of the latest research conducted on the effects of climate change on the species.

A 2015 paper published by a team of researchers from the University of Veterinary Medicine, Vienna, reveals that mild winters are becoming more frequent, and that there is a strong correlation to increasing boar numbers (Vetter et al., 2015). The scientists believe that the increasingly frequent mild winters in Europe and the subsequent increase in acorns and beechnut production by trees are aiding boar survival rates.

As we have seen elsewhere in this paper, wild boar are extremely adaptable mammals with an enormous reproductive capacity, thus providing the potential for population growth when environmental conditions become more favourable. Wild boar can have five or more young in a litter, and females can reach sexual maturity within their first year if there is enough food available.

Vetter et al.'s analysis shows that wild boar is highly susceptible to cold winter conditions, as each incidence of this was consistently followed by population declines. Cool autumns were also shown to have a negative impact on population growth (although as the models used averages this may simply reflect an early onset of winter). Climate conditions are known to be important factors influencing many ungulate populations affecting strongly juvenile sur-

vival and reproduction (Putman et al., 1996; Saether, 1997). Cold winters lead to increased juvenile mortality, which is a major driver of wild boar population dynamics. Especially frost in spring can cause juvenile mortality (up to 90% during the first two years of life). Geisser & Reyer (2005) showed a clear correlation between higher winter and spring temperatures and a stronger population growth of wild boar by reducing the mortality of wild boar piglets. Figure 26 (Geisser & Reyer, 2005) shows 8 variables related to wild boar population dynamics between 1974 and 1998 in the canton Thurgau, Switzerland. Making use of a stepwise multiple regression analysis they showed that food and temperature conditions are key factors for the fluctuation in the wild boar density. The increased winter and spring temperatures strongly influences reproduction (winter temperatures) and juvenile survival (spring temperatures).

Milder winters lead to reduced winter mortality leads to increased survival of wild boar in all age classes (Rossi et al., 1997; Melis et al., 2006).

Temperature is essential in the survival of newborn piglets (usually born in April and June).

Several studies, conducted in several parts of Europe, link changing climate conditions with the population growth of wild boar: Germany (Hahn & Eisfeld, 1998), France (Vassant, 1997), Italy (Boitani et al., 1995) and Poland (Jedrzejewska et al., 1997). Rapid population increases are typical for r-selected species that make maximal use of space and food to survive to produce a large offspring with limited survival. If the variables responsible for limiting the population growth (e.g. low temperatures in winter and in spring) the population starts to grow exponentially.

Climate change in Europe (Watson, 2001; EEA, 2004; Raisanen et al., 2004) is not only influencing population size of wild boar but also the mast availability and the production of agricultural crops. Those factors too have an impact on the exploding population size of wild boar in Europe.

According to Vetter et al. (2015) wild boar populations across Europe have been growing irrespective of whether the number of hunters has increased, decreased or remained stable. Their research therefore claims that increasingly milder winters as a result of climate change must be considered as a major reason for the European-wide increase of wild boar during the last decades.

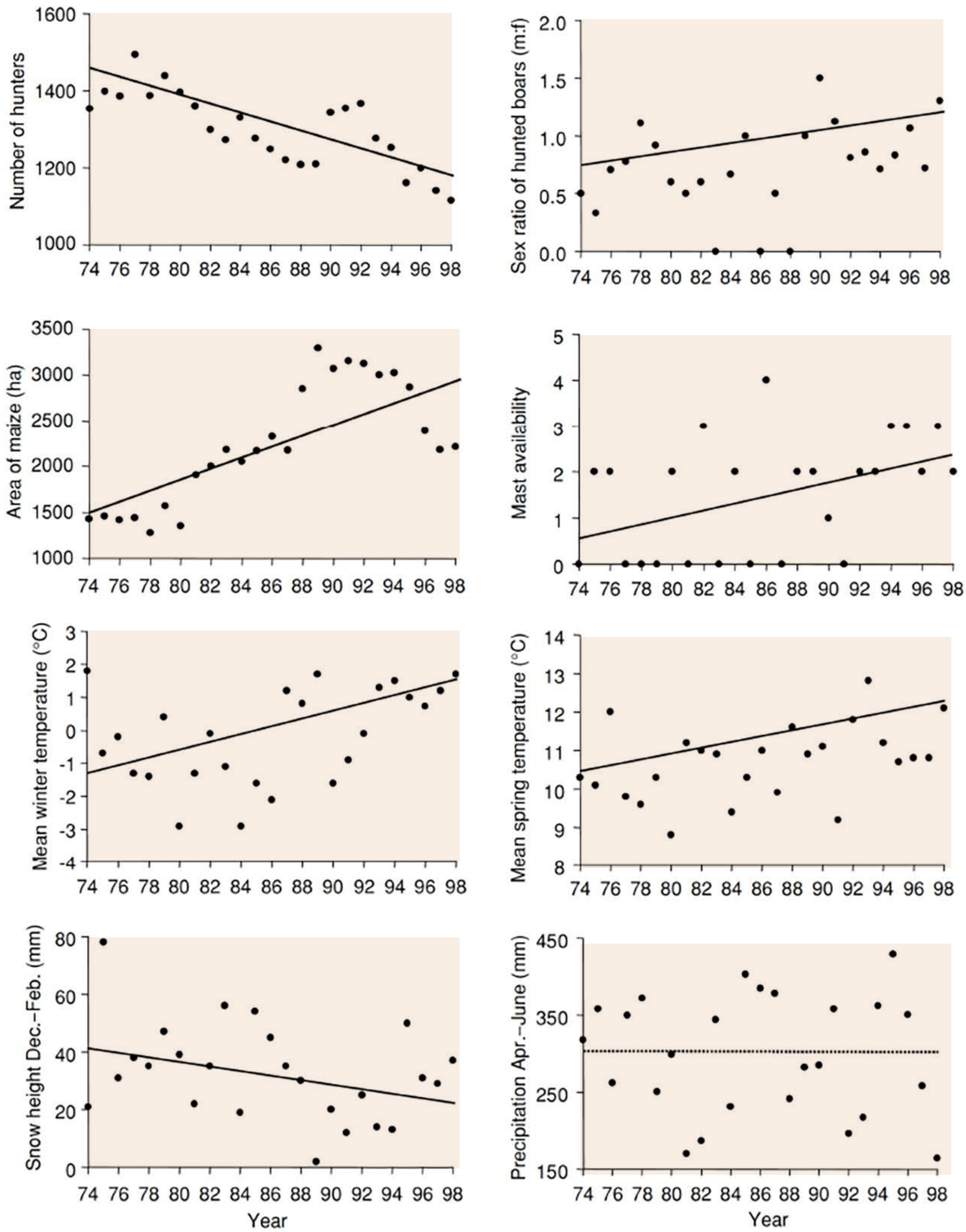

Figure 26: Eight variables related to wild boar population dynamics between 1974 and 1998 in the canton Thurgau, Switzerland. (Source: Geisser & Reyer, 2005).

Reforestation

Reforestation has been mentioned as an important variable to explain the population growth in wild boar (Sáez-Royuela & Telleria, 1986; Servanty et al., 2011). In the last 20 years the forest area in Europe increased significantly (UN-OECE-FAO, 2011) giving the wild boar the opportunity to enlarge its territory and to spread to previously unoccupied areas (Keuling et al., 2009).

Food availability

The increased availability of agricultural crops throughout the year has certainly played a major role in the growing population of wild boar (Bieber & Ruf, 2005; Geisser & Reyer, 2005, Massei et al., 1996; Maillard & Fournier, 2004; Groot Bruinderink et al., 1994).

A study by Schley et al., (2003) showed that agricultural crops represent an important component of wild boar diet throughout its Western European range.

Food availability has a direct impact on the reproductive success of wild boar (Gamelon et al., 2013)

The highest reproductive output for wild boar is directly linked to the availability of energy-rich crops such as maize and sunflower in summer and autumn (Rosell et al., 2009; Servanty et al., 2009).

Food can influence demography in 3 ways:

1. Reduction of juvenile mortality: allowing the piglets to survive the cold winter months until fall (Schauss et al., 1990)
2. Food availability strongly affects reproductive activity (Baber & Coblentz, 1985; Pepin et al., 1986), increased fertility size and larger litter sizes (Howell & Edwards-Jones, 1997; Fernandez-Llario et al., 1999)
3. Food availability affects the age of first reproduction (Saether, 1997)

Mast

Mast is the botanical name for nuts, seeds, buds, or fruits of trees and shrubs that are eaten by wildlife.

We can distinguish two main types of mast:

1. Hard mast: hard nuts and seeds such as acorns, hickory nuts, and walnuts.
2. Soft mast: berries and fruits such as crab-apples, blueberries, ...

For wild boar, hard mast is considered more important, especially as a winter food source, due to its higher energy content.

Mast seeding, or masting, refers to the synchronous production of large numbers of seeds or fruit by a population of plants. Some species (e.g. oak) occasionally have years where an entire population of trees produces an unusually large number of acorns all together. These bumper crop years are known as "mast years."

The proportion of reproducing female wild boars can reach up to 90% in good mast years compared with only 20-30% in poor mast years (Massei et al., 1996).

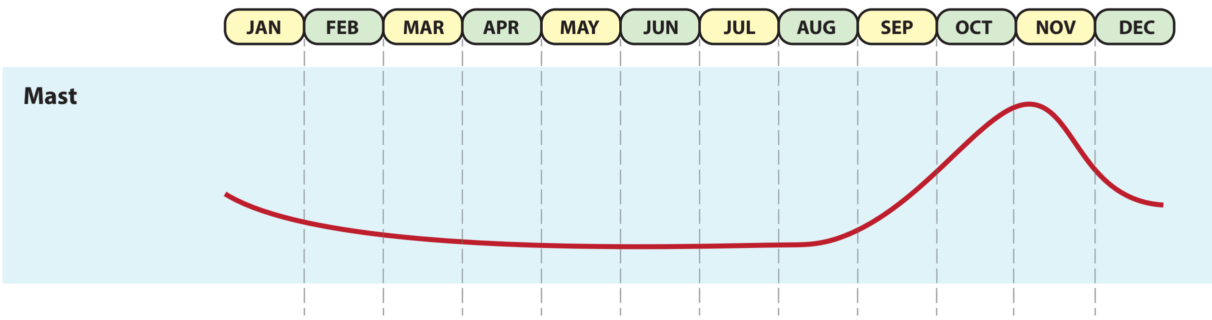

Figure 27 shows maximum mast availability for wild boar in the period September - January.
Wild boar litter size is especially influenced by the wild boar's body weight gain in this period (Baubet, 2007).

Maize

Around 15 million hectares of maize are found in the EU 28, of which 60% (9.4 million ha) is harvested as grain and 40% (5.9 million ha) as silage. Maize seed is produced on approximately 180,000 hectares (European Seeds Association, 2017). The main markets are human consumption, animal feed and bioenergy.

The total amount of maize planted in the EU increased drastically over the last 30 years. The yield progress in maize (grain) in France between 1951-2007 is shown in figure 28.

The increase in the area of planted maize throughout Europe and the higher yields are in line with model predictions on the impact of climate change on the productivity and composition of natural and anthropogenic plant communities (Watson, 2001).

Figure 29 shows maximum maize availability for wild boar in the period August - November.

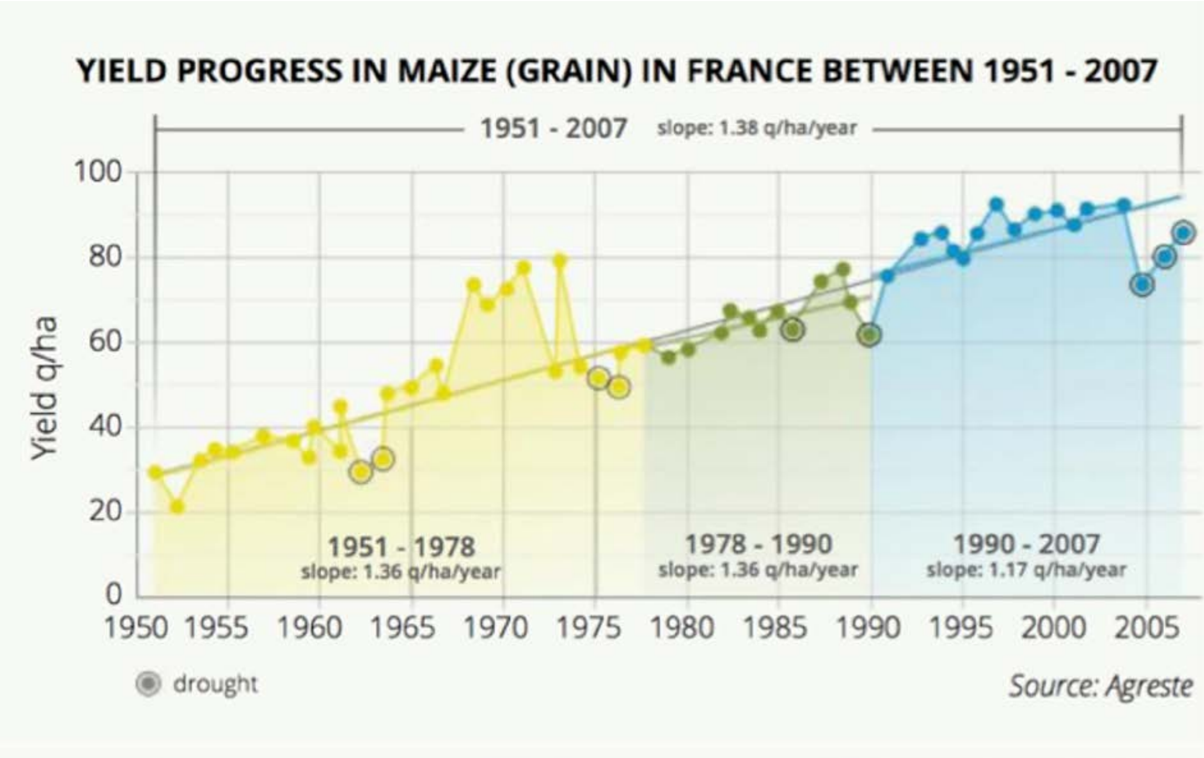

Figure 28: yield progress in maize (grain) in France between 1951- 2007. Source: French Ministry of Agriculture.

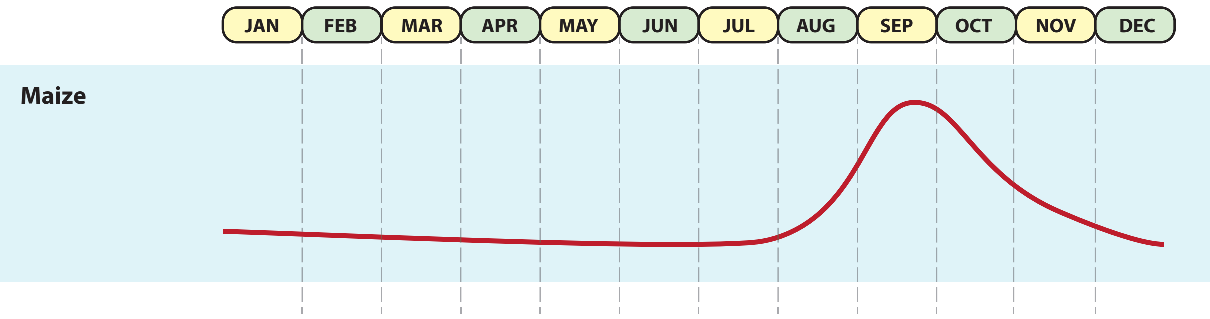

Figure 29: maximum maize availability for wild boar in the period August - November.

Rapeseed

Rapeseed, also called colza, is a member of the Cruciferae family. It grows to a height of 75-175 cm. Rapeseed has yellow flowers, blue-green leaves and is heavily branched with deep, fibrous taproot. Rapeseed has small, round and black-red seeds. It is grown for the production of animal feed, edible vegetable oils, and biodiesel. In Europe, rapeseed is primarily cultivated for animal feed, due to its very high lipid and medium protein content (Heuzé et al., 2017).

Rapeseed actually comprises several different but similar varieties: Brassica napus (rapeseed) and Brassica rapa (turnip rapeseed). The EU produces 23 million tonnes of rapeseed (a thirty-fold in 30 years), imports 3 million tonnes and exports about 0.5 million tonnes per year. Figures 30 and 31 show area on which rapeseed is cultivated and the total production of rapeseed in EU Member States in 2017. Figure 32 shows maximum rapeseed availability for wild boar in the period June - August.

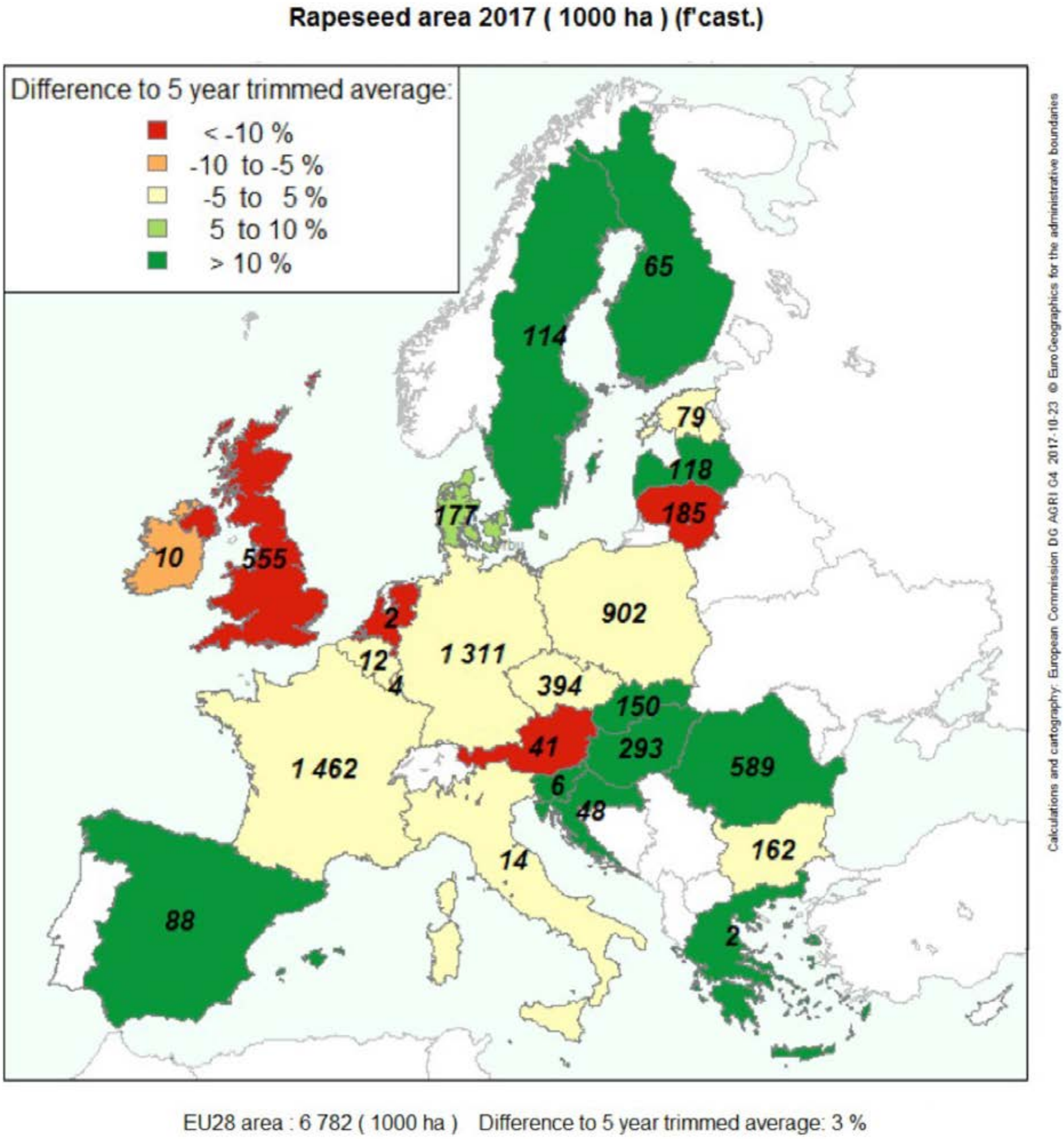

Figure 30: Rapeseed area 2017. Source: European Commission DG AGRI https://ec.europa.eu/agriculture/sites/agriculture/files/cereals/presentations/cereals-oilseeds/market-situation-oilseeds_en.pdf (retrieved on 4 January 2018)

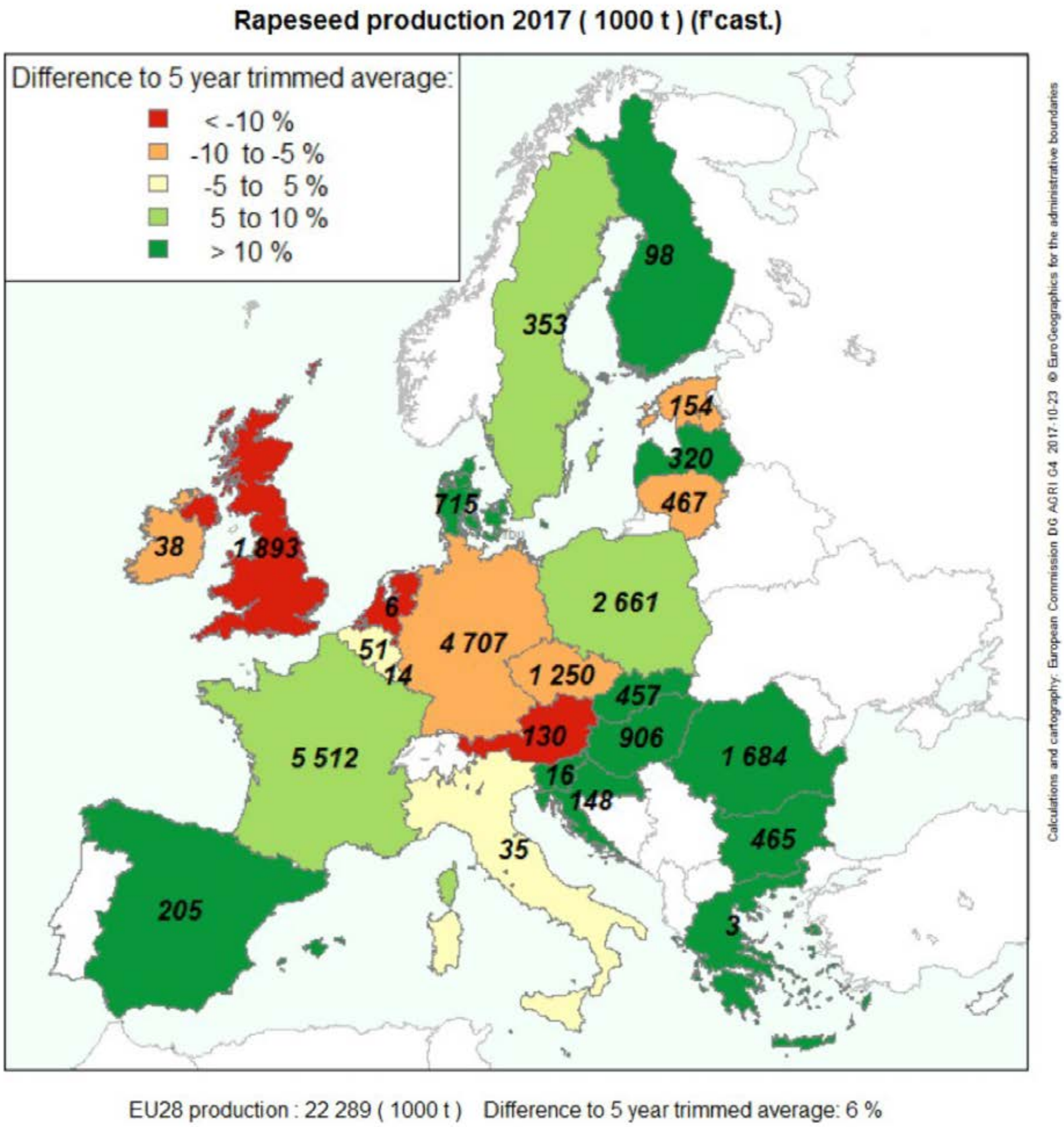

Figure 31: Rapeseed area 2017. Source: European Commission DG AGRI, https:// ec.europa.eu/agriculture/sites/agriculture/files/ cereals/presentations/cereals-oil- seeds/market-situation-oilseeds_en.pdf (retrieved on 4 January 2018)

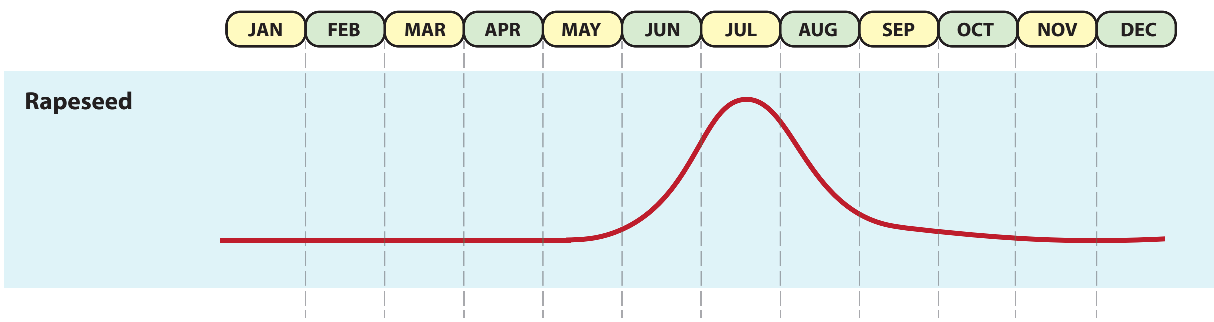

Figure 32: maximum rapeseed availability for wild boar in the period June - August.

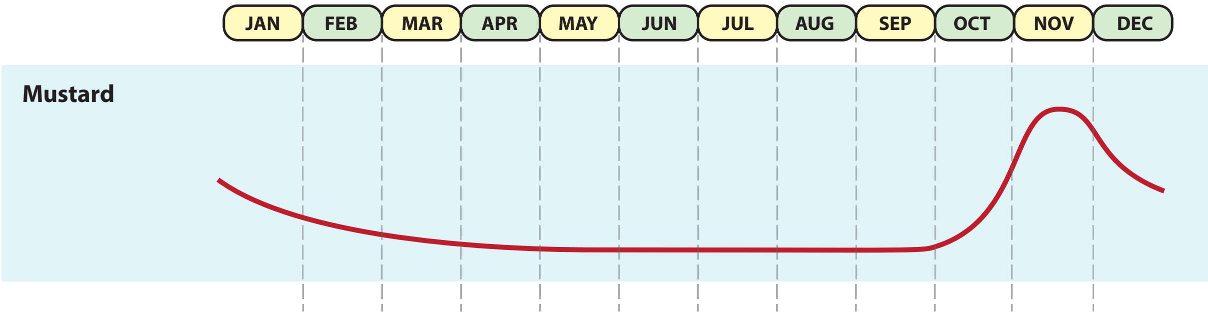

Figure 33: maximum mustard availability for wild boar in the period October - February.

Mustard

Mustard plants are any of several plant species in the genera Brassica and Sinapis in the family Brassicaceae.

Mustard can be cultivated in order to harvest the seeds to be used as a spice. However, mustard was also prescribed by the EU as one of 19 different types of land use that may count as EFA (Ecological Focus Area). When planted as a non-agricultural crop, i.e. as buffer strips along water bodies or to maintain landscape elements such as hedges or ponds, mustard conforms to greening measures within the Common Agricultural Policy of the European Commission. Farmers may also plant legumes like peas, beans or lupine, which fix nitrogen from the air into the soil. They also can plant 'catch crops' like mustard or rapeseed to cover the soil surface over the autumn and winter to prevent soil erosion between harvest and the next planting. Due to this, mustard cultivation, which was almost non-existent 20 years ago, has now become widespread across Europe.

Figure 33 shows maximum mustard availability for wild boar in the period October - February.

Responses/solutions

Sus scrofa is widespread across many landscapes throughout Europe. The species is considered by many to be an invasive pest and detrimental to agriculture and the environment (Sáez-Royuela & Tellería 1986, Neet 1995, Leaper et al. 1999, Bieber & Ruf 2005). The species was listed as among 100 of the "World's Worst Invaders" by the IUCN's Invasive Species Specialist Group (Lowe et al. 2004). Others however view them as a native game species and a valuable resource for hunting. But even where wild boar is a native, or valuable species, it may still be viewed as problematic if populations are perceived as too abundant.

The task of wildlife management plans is to ensure that numbers are maintained at the correct level to minimize damages while ensuring that populations can regenerate adequately. Sustainable management is seen as vital to ensure field crop damage prevention, as well as for the implementation of sustainable hunting policy.

While there is an overwhelming number of scientific articles describing and discussing problems related to the wild boar population (and its growth), only limited information is present on possible solutions.

Three main methods are used to reduce wild boar damage (Briederman, 1990):

1. Intensive harvest of wild boar
2. Supplementary feeding in forests to bait wild boars for harvest or to keep them out of the farmland
3. Fencing to stop wild boars from entering the fields

Each of those methods recommended are prevention measures in scientific and popular articles (Breton, 1994; Mazzoni della Stella et al., 1995; Vassant, 1997). All three methods are officially supported by many European wildlife management agencies (Geisser & Reyer, 2004). However, there is a clear need for additional research on how to tackle the problem of the fast-growing wild boar population in Europe.

Hunting

Hunting can significantly reduce population density (Sweitzer et al., 2000; Geisser & Reyer, 2004) and damage frequency (Mazzoni della Stella et al., 1995; Geisser & Reyer, 2004). Damage is only reduced when population and dispersal is controlled. Battues are the most effective method of population control (Geisser & Reyer, 2004). However, due to the high reproductive potential of wild boars the effect of harvesting is small (Jezierski, 1977). Up to 90% of all female wild boars can reproduce within a single season (Massei et al., 1996).

Selective harvesting of females could effectively reduce population size (Briedermann, 1990) and Bieber & Ruf (2005) indicate that strong hunting pressure on adult females would lead to most effective population control in years with unfavourable conditions, however, sex determination of younger wild boar is however difficult in the field.

Magnien (2017) describes the effect of hunting on specific age classes of males and/or females. He clearly shows that shifting hunting practices towards the targeting of specific age classes (60% of the offspring comes from wild boars under the age of 2 years and more than 30% comes from wild boar under the age of 1 year) can have a significant effect on the population size. Bieber & Ruf (2005) study indicate that, in favourable environmental conditions, reducing juvenile survival will have the largest effect on population numbers.

A thorough and targeted approach to harvesting, in particular making use of battues, seems to be the most effective means of population management (Geisser & Reyer, 2004; ELO, 2012, Giménez-Anaya et al., 2017). However, battues are subject to much stricter policies in terms of seasonal restrictions.

Supplementary feed

To optimize harvest efforts hunters often maintain feeding stations in forests. Supplementary feeding could also be useful for enhanced monitoring and research efforts. Several studies provide evidence for a successful reduction of damages using supplementary feed (Andrzejewski & Jezierski, 1978; Meynhardt, 1991; Vassant, 1994), however others find no significant reduction (Hahn & Eisfeld, 1998, Geisser & Reyer, 2004).

Careful planning, coordination and timing of supplementary feeding is vital to ensure success (Geisser & Reyer, 2004). Brandt et al. (2006), and Baubet et al. (2008) demonstrate that careful planning of supplementary feeding leads to less agricultural damage. Vial (2012) demonstrates that the prohibition of supplementary feeding is resulting in additional damages to agricultural crops.

In order for supplementary feeding to reduce damage on agricultural crops, strict rules must be followed. At no time the density of the feeding stations should be more than 0,67/100ha and the distance to farmland should be more than 500-1000 meters (Bahr, 1996; Berger & Gauville, 1994). A higher density of feeding stations may even result in attracting wild boars to forests they would not go to or in attracting wild boars in to the agricultural land due to the short distance between feeding stations and the farmland.

Figure 34 shows maximum availability of mast, maize, rapeseed and mustard for wild boars. Supplementary feed is unable to compete with the large quantities of mast and crops available. However, in the period February to May those crops do not provide food for wild boar. During this period, supplementary food could be very effective to concentrate wild boar (Figure 35).

Figure 36 shows that during the exact period where supplementary food could be an effective tool for population management, the hunting season for wild boar is closed in many EU member states. In those member states where the hunting season is open in this period, there are often restrictions on hunting practices (e.g. battues). This is the period when there are the most opportunities to develop more effective hunting practices in order to reduce the wild boar population in Europe.

When there is a food shortage (winter and spring) wild boars tend to increase their range in order to find new food sources to survive. This has implications for both the spread of transmissible diseases and the potential for damage to agricultural crops and property. In those cases, additional feeding can limit the dispersal of wild boar populations. High energy food such as maize is especially efficient in those cases.

The effectiveness of supplementary maize feeding in avoiding the dispersal of wild boar depends on when and where it is provided. In regions where maize is grown widely, supplementary feeding would only be effective in the period between mid-November to the end of May when maize is no longer present in the field. In regions where no maize is grown, the supplementary feeding of maize can be effective throughout the year as it is not competing with other sources.

Baubet (2007) demonstrates that litter size is especially influenced by the wild boar's body weight gain in autumn. The wild boar's body weight stabilizes in autumn when the total amount of food is lower than 700g/day/animal (Mauget & Pépin, 1985). During this period, wild boar has access to mast feeding, maize and mustard.

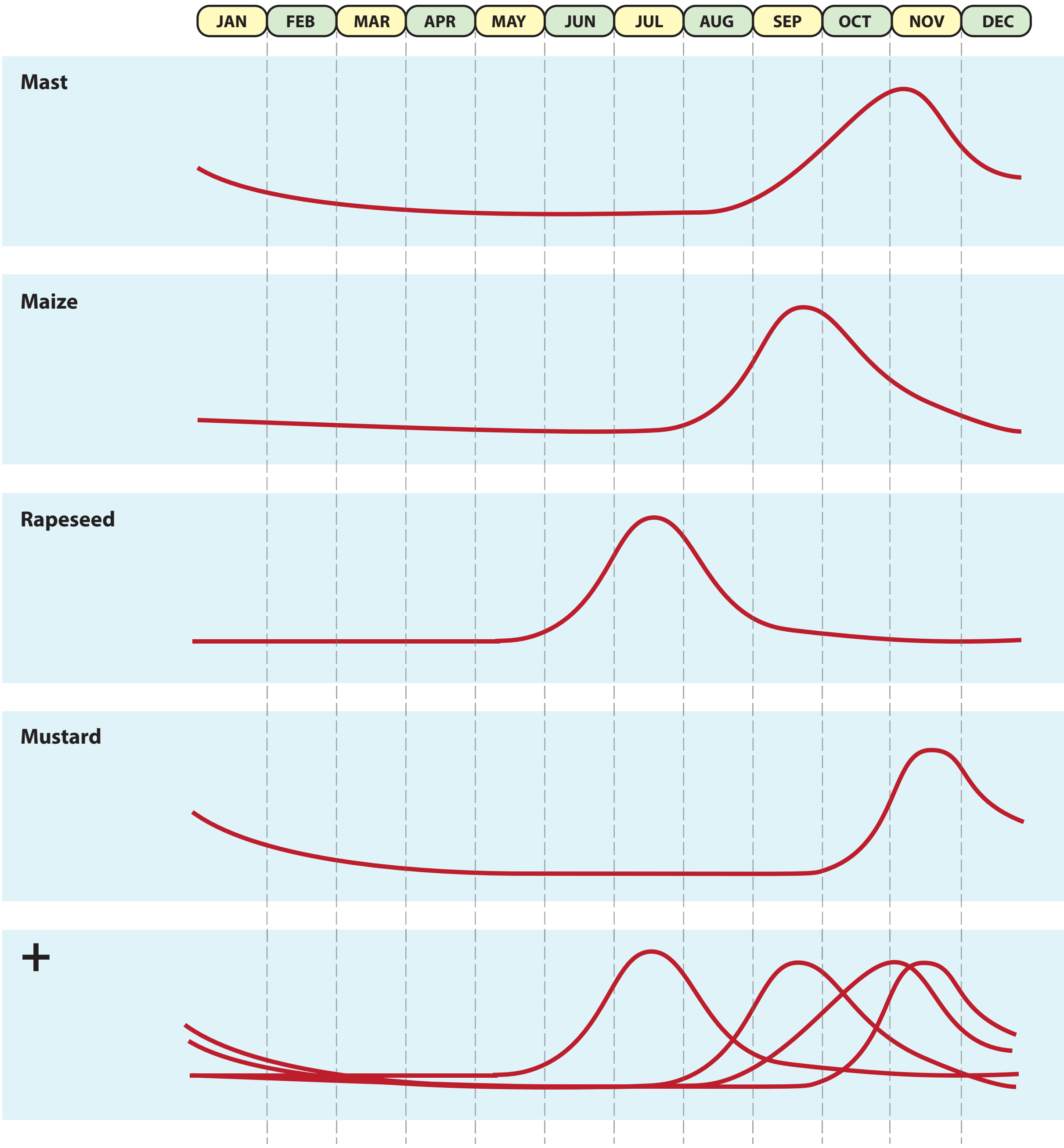

Figure 34: Maximum availability of mast, maize, rapeseed and mustard for wild boars.

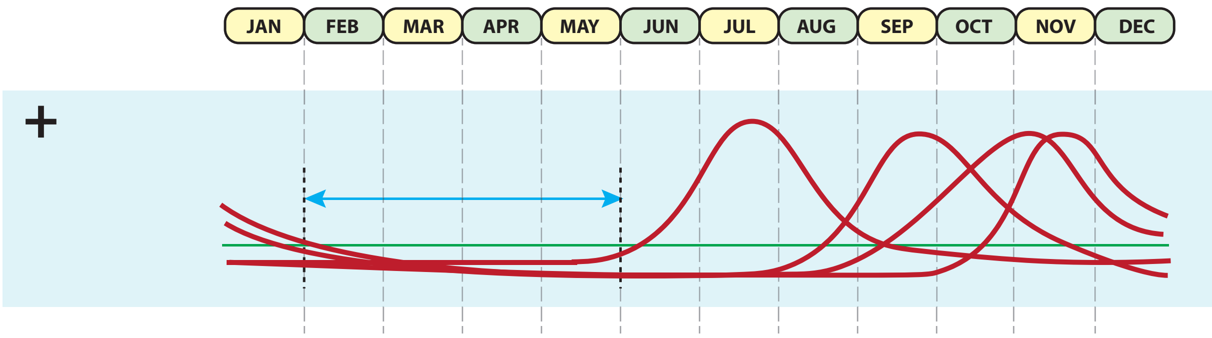

Figure 35: Optimal period to apply supplementary food.

Figure 36: Optimal period to apply supplementary food in function of hunting season on wild boar.

Fencing

Some authors recommend fencing as the most successful method of damage prevention (Vassant & Boisaubert, 1984; Baettig, 1988; Bouldoire, 1990; Breton, 1994; Vassant, 1994). Geisser & Reyer (2004) did not see a significant impact. However, wild boar can jump up to 1.5 meters in height, any fencing would need to be high enough and strong enough to restrict their movement effectively. This would require considerable financial investment to protect crops. Fences can protect limited areas to a certain extent but may result in additional damage in adjacent areas or in less protected areas (Geisser & Reyer, 2004) and to their cultures (e.g. grassland).

Management

When properly managed wild boar populations can contribute to the local economy, especially in regions where agriculture is less significant and there is less potential for conflicts. Wild boar can provide income from tourism, hunting activities, regional produce etc. When the population is kept under strict control the species is not a threat to biodiversity or forestry. In regions with limited agricultural activities or in fenced areas without agricultural activities the population growth can be controlled and the access to food can be better regulated. Large populations combined with supplementary food should not be permitted in such areas (Magnien, 2017).

Better support

There is a clear need for hunters, farmers, landowners, and nature conservationists to better understand the interconnected causes of increasing wild boar populations across Europe. Wildlife management practices should be based on clear empirical evidence and best practices should be shared and applied where most effective.

Informed and strategic hunting practices are necessary to successfully reduce wild boar populations in Europe, i.e. shifting hunting practices towards targeting specific age classes to best control population size. Hunters, conservationists and researchers must work together to generate and compile datasets and develop methodologies for effective population mapping and management.

A number of organizations promote the role of sustainable hunting practices as a key element of wildlife and biodiversity conservation strategies.

Wildlife Estates Label

Wildlife Estates is a conservation initiative that promotes sustainable land use and wildlife management practices in privately held land throughout Europe. It helps build recognition and raises standards amongst small-scale conservation efforts, through the introduction of an objective accreditation system and a certification process. It is now the largest privately-owned land conservation label in Europe.

European habitats are threatened by a variety of factors due to changes in land-use, intensification and conversion of production systems, abandonment of traditional practices which are often biodiversity-friendly, infrastructure developments, urbanization, and lack of funds to support rural communities. The result is ecosystems and landscapes that are fragmented and degraded.

Climate change, pollution and the spread of invasive alien species add to the existing stress. In the face of these challenges, Wildlife Estates has succeeded in creating and improving habitats in favour of biodiversity, as well as in restoring natural conditions where game species can thrive.

The project relies on the collaboration from Europe's farmers, foresters, hunters and anglers, who all are indirect producers of wild flora and fauna. They are the key link to halting biodiversity loss. By demonstrating that sustainable rural development does not need to come at a cost to biodiversity, the label advocates for the concept of "conservation through wise use." This embraces not only responsible exploitation of wildlife via rural activities, but also the beneficial role that active and positive management plays in ensuring the survival of European ecosystems.

It is based on the adoption and implementation of a set scientifically developed measures designed to manage wildlife on privately held land across Europe. These activities are either targeted at enhancement of the survival and productivity of certain species, or the management of the abundance of others in order to reduce their impact on the wider biosphere.

Rural estates are crucial in supporting rural economies, which in turn play a significant role in overcoming the world's food, energy and environmental challenges. In order for rural development to be environmentally sustainable both private initiatives and the support of public instruments are vital.

As environmental degradation accelerates, the role of private land managers becomes increasingly important in preserving nature and landscapes through active management practices. This is why the WE Label has sought to facilitate collaboration between private and public actors. It has done so, in order to illustrate that the work undertaken by landowners is very much in line with the fundamental philosophy of biodiversity conservation.

The Wildlife Estates Label was conceived in 2005, since then the project has expanded progressively to promote biodiversity conservation in the face of emerging political, economic and social concerns at both the EU and local levels.

Today, the Wildlife Estates Label is represented in 19 countries with over 300 labelled estates, covering over 1,500,000 hectares across Europe. The sizes of labelled estates range from small-holdings a few tens of hectares to commercial estates covering tens of thousands of hectares. Nevertheless, they are all fundamentally united in their goal to preserve and enhance their natural environment.

For more inormation visit: www.wildlife-estates.eu

Conclusions and policy recommendations

Conclusions

1. Localized analyses indicate that wild boar populations have increased significantly across Europe over the past 30 years.

2. The increase in wild boar populations is affecting the distribution of diseases, affecting human and animal health, contributing to negative wild-boar interactions, and causing damage to agricultural crops and biodiversity. These effects also have a direct economic impact.

3. The number of road accidents involving wild boars is growing.

4. Hunting has not prevented the growth of wild boar populations. However, it is likely that without hunting the problem would be worse.

5. Evidence indicates that a combination of factors, including decreasing trends in the number of hunters, changing hunting practices, reforestation, increased food availability (mast, agricultural crops), affect wild boar population growth.

6. It is clear that the primary factor responsible for the increased wild boar populations in Europe is climate change. Milder winter and spring temperatures strongly influences reproduction (winter temperatures) and juvenile survival (spring temperatures). Climate change also influences food availability (mast and agricultural production) further reinforcing the favourable effects of climate change on the species.

7. Changing agricultural practices have created favourable conditions for the growth of wild boar populations:
   - The availability of multiple food sources;
   - Tranquillity and shelter which is no longer provided by a majority of forested areas.

Recommendations

1. Create a comprehensive European database on wild boar populations. The present lack of robust data on a European scale can only be addressed through a collaborative effort of the scientific, hunting and nature conservation communities. Developing common European monitoring methodologies to gather objective data and pooling the existing data (from hunting bags and localised research studies) would lead to better, more effective management of wild boar populations and less negative human-wild boar interactions.

2. There is a need for substantial changes to hunting practices in order to keep wild boar populations under control:

   - A shift towards targeting specific age classes (60% of offspring are born to wild boars aged 2 years or less, and more than 30% from wild boar under the age of 1 year) in order to limit population growth;
   - Use of the most performant hunting methodology;
   - Reducing restrictions on battues throughout the year;
   - Longer hunting periods (year-round).

3. Supplementary feeding in order to avoid further spreading of wild boar populations outside of its traditional environment should be authorised but should be better coordinated and regulated. There is a need for a more scientific approach.

4. In view of the changing behaviour of wild boar populations and changing agricultural practices responsibility must be shared by all stakeholders involved.

5. The general public should have better access to information on potential negative wild boar-human interactions and how to avoid them.

6. Co-operation between governments, scientists, landowners, hunters and conservation groups should increase. Close collaboration between farmers and hunters is vital to ensure that the necessary precautionary measures to avoid damages caused by wild boar are implemented.

7. Strategies to reduce human-wild boar conflict should be developed and adopted.

8. Better support mechanisms should be provided to private wildlife managers (e.g. Wildlife Estates Label)

9. The above recommendations should be combined and local conditions should be taken into account in their implementation.

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