

Management of red deer and fallow deer in Sweden



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Preface

This is a report produced on behalf of the Danish Environmental Protection Agency. An adaptive management plan for red deer and fallow deer in Denmark is to be produced and launched in 2026. In order to produce an expedient plan, there is an interest to learn about experiences of red deer and fallow deer management outside Denmark.

This report deals with two assignments. The first assignment is to review and analyse management of red deer and fallow deer in Sweden. The second assignment is to relate monitoring methods used for red deer and fallow deer in Sweden.

The report is partly a review of scientific literature, authority reports, management books, news media, records and protocols from meetings. Additionally, I have interviewed wildlife managers, hunters and other persons involved in management, particularly in fallow deer management. I also relate to my own experience of red deer. I have been working with red deer management and monitoring since 1995, and have been conducting research on red deer since 2005. During the last 20 years I have been giving numerous lectures on red deer ecology and management to hunters, landowners, and authorities all over Sweden and have gotten an insight in red deer management from south to north.

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Summary

Red deer is a native species in Sweden, but was nearly exterminated in the early 20th century. Only a small population in southern Skåne survived. From the late 1950s and onwards, legal introductions as well as escapes from enclosures has led to a wide, but scattered distribution, with red deer in nearly all provinces. From 150 deer in Skåne in the 1950s, the population has increased to a present population of 26 000. Fallow deer was introduced in enclosures in the late 16th century, but wild populations did probably not occur until during the 19th century. During the 2000s the species have shown a strong increase and the annual harvest now exceeds 70 000 with fallow deer populations mainly in the southern third of Sweden.

Outside Skåne, red deer are managed in Red deer management units. These are registered at the County Administrative Boards and should preferably have a size of at least 10 000 ha. The management unit shall present a three-year plan with aims for the management, planned annual harvest, and measures taken to reduce damage and deer-traffic collisions. Hunting units not registered in a management unit are allowed to shoot calves 16 August – 31 January. In red deer management units females and calves are allowed 16 August – 28 (29) February. Males are allowed 8 October – 31 January.

In southern Skåne there is a management area for the nominate subspecies of red deer. In this area harvest is license regulated and hunting units must apply for red deer licenses at the County Administrative Board. Outside the management area (mainly northern Skåne) there is a general open hunting season with no regulations regarding age, sex, or number of deer harvested. The hunting season in Skåne is 8 October – 31 January.

There is a general open season for fallow deer in Sweden, i.e. there is not a need for any special permits, and there are no regulations regarding size of a hunting unit or regarding number of deer that can be shot in a hunting unit. Males and calves are allowed during 1 – 30 September. All animals are allowed during 1 – 20 October, and 16 November – 28 (29) February. Females and calves are also allowed 21 October – 15 November and 1 – 31 March.

Several faults have been identified for the work in Red deer management units, but most of these can be related to a lack of support from the authorities, a lack of knowledge and experience of red deer, and a lack of reliable population data. To counteract these problems, it has been suggested that the Red deer management units should be included in the Moose management system.

The license regulated management in Skåne has proven efficient to reach and sustain goals regarding population size and age and sex ratios.

The large increase in fallow deer numbers in Sweden can to a large extent be explained by the absence of harvest regulations. An overharvest of males, and a low harvest of females, have led to rapidly increasing female-biased populations with a low male ratio and a low average age of males. As a consequence damage has increased as have the permits for protective shooting. In the counties of Södermanland, Östergötland, and Västergötland, general year round protective shootings have been proclaimed. A reaction to the increasing fallow deer numbers, is that voluntary fallow deer management units have been formed in Skåne, Södermanland, and Östergötland. The main goals are to decrease damage by lowering population density through an increased female harvest, and to increase male ratio and male average age. However, they have problems reaching these goals, mainly due to hunting units that do not participate in the management unit, and continues to mainly shoot males.

There is a need for reliable and cost-efficient monitoring methods for both red and fallow deer. Several monitoring methods are used for red deer in Sweden, but no one stands out as the one to recommend. In Skåne, however, a census during the rut seems to serve the management well. The common method for surveying fallow deer in Sweden is a spring count. The method has, though, not been tested regarding reliability. Rather than going for expensive and resource consuming absolute counts of population size or density, it is probably better to aim for reliable indices of population trends and changes of population composition.

1. Management of red deer and fallow deer in Sweden

Anders Jarnemo

1.1 Red deer – History of distribution and present population

1.1.1 Prehistoric distribution of red deer in Sweden

After the last glaciation, red deer (*Cervus elaphus*) immigrated 8 000 B.C. to the province Skåne in southernmost Sweden (Ahlén 1965a). The species reached a maximum distribution in Sweden covering the provinces (Appendix 1) Skåne, Blekinge, Halland, Småland, Öland, Östergötland, Västergötland, Bohuslän, and Dalsland. There are archaeological findings of red deer also in Dalarna and Gotland, but these may be a result of translocations by humans (Ahlén 1965a).

1.1.2 Distribution of red deer in historical time in Sweden

Red deer disappeared from most of its former range in Sweden during the 18th and 19th centuries. When the last deer in Västergötland was killed in 1847, red deer only remained in Skåne. It was probably a combination of several factors that led to the extinction of red deer in the provinces north of Skåne (Ahlén 1965a). An increased human land use including a deforestation of the landscape and extensive grazing of domestic animals in the forests decreased availability of habitat and forage. Wolves (*Canis lupus*) were abundant and predation together with hunting and poaching added further pressure to the decreasing populations. The cooler climate during the Little Ice Age (Matthes 1939), is likely to have strengthened the effects of the factors above. When the royal hunting privileges were abolished in 1789, the uncontrolled hunting soon led to an extermination of already declining occurrences.

The total Swedish red deer population was then confined to some larger estates in south-central Skåne. During the 19th century the population size in Skåne varied between 100 and 300. There were also temporal variations in distribution with local sub-populations in different areas and estates arising, increasing, decreasing, and disappearing. In an almost cycle-like manner, periods of protection with population increases were followed by increases in harvest due to severe damage. In combination with harsh winters and increased poaching, the number of deer then declined, evoking calls for protection of the deer. A bottom out was reached in 1907 when the number of red deer in Skåne (and in Sweden) was estimated to approximately 50 (Ahlén 1965a, Lavsund 1975).

1.1.3 Planned reintroductions and escapes from enclosures

A debate over whether red deer should be preserved or exterminated in Skåne started in the early 20th century (Lavsund 1975, Ekman 1990). The extermination side argued that red deer caused too much damage to forest plantations and crops, whereas the preservation side argued that the red deer as a native species had a right to exist and be part of the natural fauna. This debate continued and led to two separate actions; the introduction of red deer further north in Sweden in the 1950s and the 1960s, and a reserve for free-living red deer in Skåne.

Already in 1918, it was suggested that the red deer in Skåne should be translocated to further north in Sweden, as the northern type of forest landscape was thought to be less vulnerable to severe red deer damage on forest plantations (Ekman 1918). The suggestion was reactivated in 1948 (Berg 1948), and in 1957-58 red deer were released in Västergötland and in Västmanland (Lavsund 1975). Subsequent releases were made during the 1960s, e.g. in Närke, and in Södermanland. From the beginning the idea was to capture red deer in Skåne that should form the founding populations in the release sites. This was also done, but animals coming from various enclosures where the deer had ancestors of a mixed origin were also released. Furthermore, alongside these planned reintroductions, red deer had escaped from enclosures (the number of red deer enclosures was 40 in 1973, containing about 600 deer) in several places, e.g. in Blekinge, Småland, Södermanland, and Uppland, and these deer were also of a mixed origin (Lavsund 1975). The red deer in Sweden outside southern Skåne are thus a mix of deer of different lineages from different areas in Europe (Höglund et al. 2013).

1.1.4 Reserve in Skåne

In 1971 a 44 000 ha reserve for free-living red deer was established in south-central Skåne. The purpose was to preserve a population of the original Swedish red deer, the so-called nominate subspecies *C.e.elaphus*, but also to balance sex ratio and increase the ratio of mature stags (Ahlén 1965a, 1965b, Sinding-Larsen 1983, Ekman 1990). The population in Skåne had shown a slow increase during the 1900s. In 1917 it was estimated to approximately 100, in 1950 to 180, in 1963 to just below 200, and in 1971 to 300 (Ahlén 1965a, Lavsund 1975). In the reserve hunting was regulated by license, and damage on crops and forest plantations was financially compensated, alongside that measures to counteract damage were taken. Outside the reserve, hunting was unregulated in a general open season in order to counteract damage, and to decrease the risk of red deer of mixed origin immigrating from the north (Sinding-Larsen 1983, Ekman 1990).

The reserve was terminated in 1988 (Jakt- och viltvårdsberedningen 1983, Larsson et al. 1987, Ekman 1990). The population within the reserve had then increased and the total population in Skåne was estimated to approximately 400 deer. One notable effect was that the number of stags with large antlers had increased, probably due to the strong restrictions regarding the possibility to harvest stags in the license system, leading to an increase of mature males (Larsson et al. 1987, Ekman 1990). Documentation of individual stags had also revealed that males made seasonal migrations between the rutting areas and areas where they spent rest of the year. These migrations could often span distances of 10-30 km, and it was then also discovered that males that rutted in the reserve could migrate to areas outside the reserve, where they were in risk of being shot (Sinding-Larsen & Larsson 1979, Sinding-Larsen 1983, Jarnemo 2008).

1.1.5 Red deer populations in Sweden from 1973 to present

From 1973 to the end of the 1980s, red deer harvest in Sweden increased from 135 to 600. Utilization rate of the license seldom reached 50 %, and varied between 30 and 46 % on a national level (Lavsund 1990). In 1973 the total population in Sweden was estimated to 800 – 1 000, with the largest numbers in Skåne, Blekinge, and Södermanland, and with red deer established in approximately 15 areas, (Lavsund 1975). These 15 areas acted as centres for a continued spread. In 1980 the harvest reached 300, and a rough estimate in the end of the 1970s, suggested a population of about 1 500 deer. (Jakt- och viltvårdsberedningen 1983, Lavsund 1990). In 1989 the number of red deer in Sweden was estimated to 2 800 – 3 500, with the strongest populations in the administrative counties (Appendix 2) of Södermanland-

Östergötland, Kalmar, Västmanland, and Skåne (Figure 1, Table 1). In 1995 the population was estimated to between 3 540 and 4 240 (Wahlström 1996, Table 1) and in 2007 to 6 800 – 10 300 deer (Bergström & Danell 2009). In 2016 to 26 000 with the largest populations in Södermanland, Östergötland, Kalmar, and Skåne (Svenska Jägareförbundet 2016) (Figure 3). The harvests of 2015/2016 and 2022/2023 (Figure 2, Viltdata, The Swedish Association for Hunting and Wildlife Management, data downloaded 27 November 2023) are nearly the same, which suggests that the present population size in Sweden is approximately the same as in 2016.

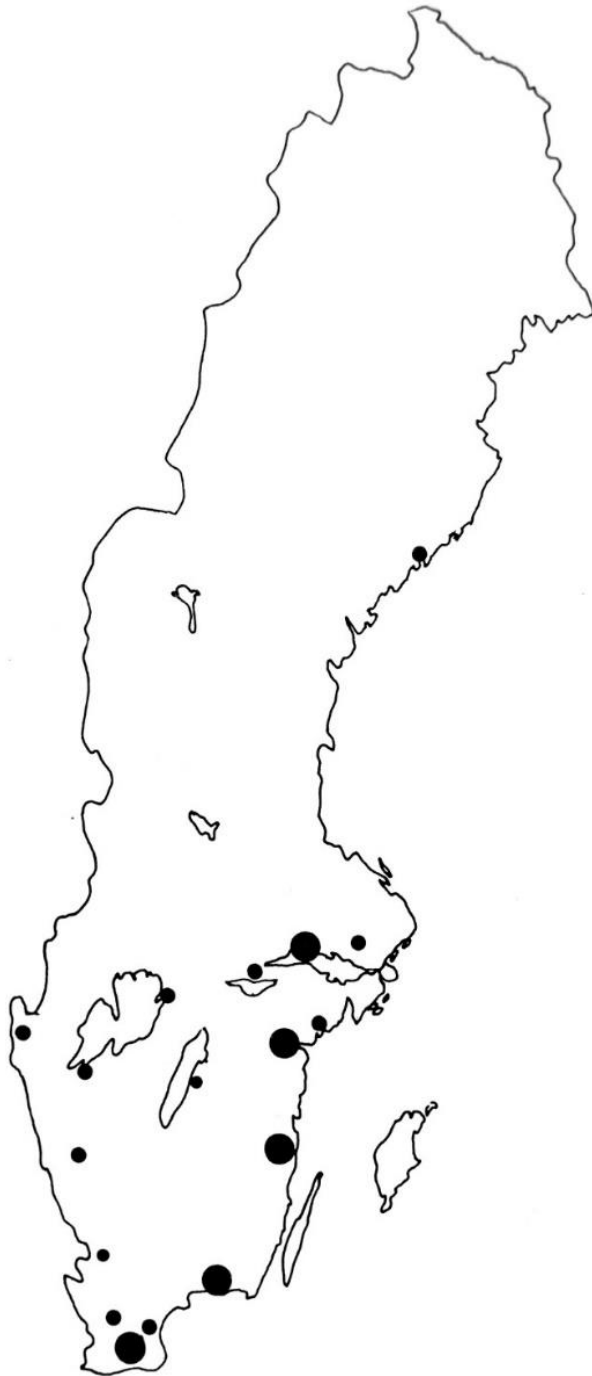


Figure 1. Distribution of red deer in Sweden 1989. The size of the filled circles indicates larger and smaller populations (From Lavsund 1990.).

Table 1. Number of red deer in Sweden in 1989 (Lavsund 1990) and in 1995 (Wahlström 1996) with distribution for the administrative counties (Appendix 2). In general, the figures are rough estimates, and seldom a result of solid censuses, wherefore the data should be treated with caution. *The former counties of Älvsborg and Skaraborg have been joined with Västra Götaland into one county.

Administrative county	No. deer 1989	No. deer 1995
Stockholm	100	50
Uppsala	100	50 – 100
Södermanland and Östergötland	600 – 1 000	1 500
Jönköping	Some occurrences	
Kalmar	500 – 600	500 – 700
Blekinge	250	100 – 150
Skåne	400	400 – 500
Västra Götaland (incl. Älvsborg, Skaraborg*)	350 - 450	200 – 250
Värmland	Some occurrences	20
Västmanland	400 – 500	500 – 700
Västerbotten	50	150
Dalarna		20
Jämtland		50 – 100
Sweden, total	2 800 – 3 500	3 540 – 4 240

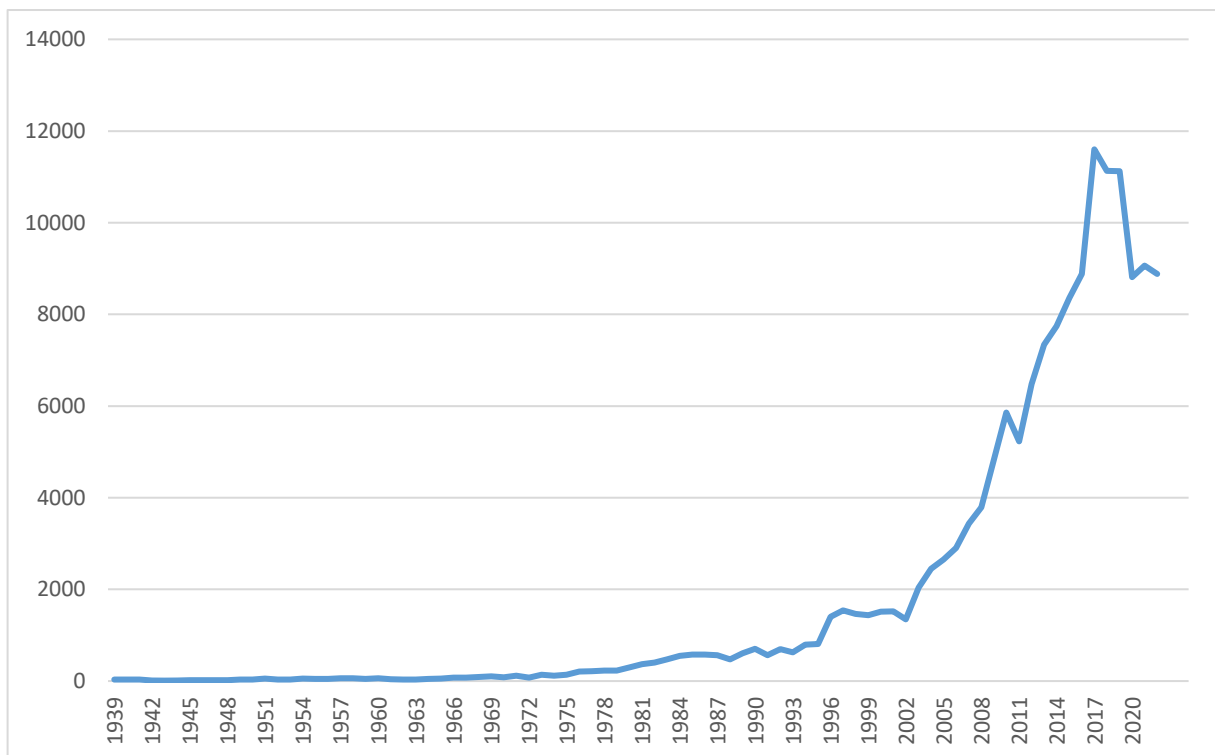


Figure 2. Red deer harvest in Sweden 1939 - 2022 (Viltdata.se, The Swedish Association for Hunting and Wildlife Management, data downloaded 2023-11-27).

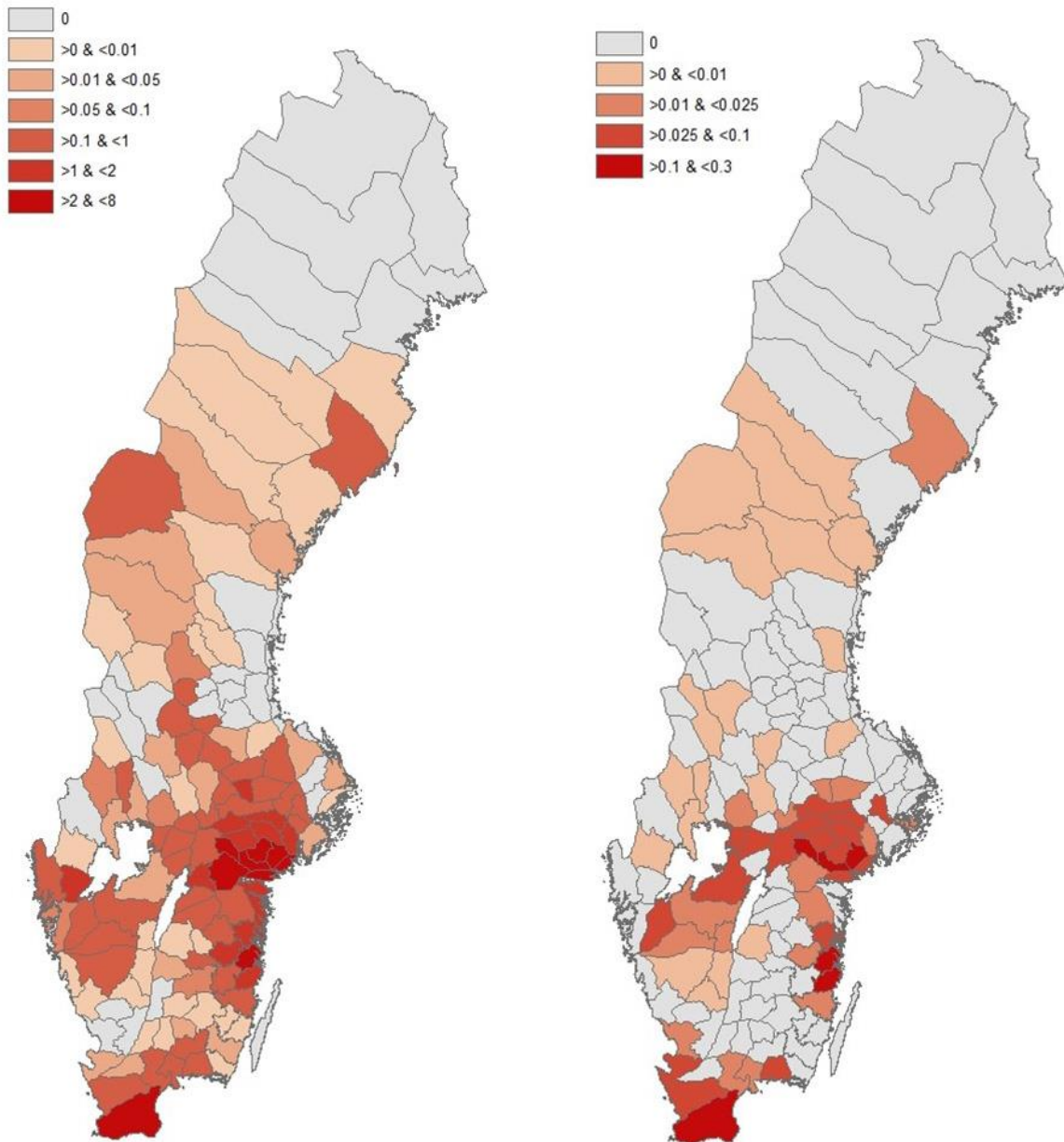


Figure 3. Red deer harvest (left), and number of traffic collisions involving red deer (right) in Sweden for the hunting season 2015/2016 (deer/1 000 ha). (From Jarnemo et al. 2018.)

1.2 Fallow deer – history of distribution and present population

1.2.1 Introduction of fallow deer

The first known introduction of fallow deer (*Dama dama*) in Sweden was in 1579 when king Johan III imported a group of deer from England. There are, however, sayings of a previous fallow deer existence in western Sweden (Ramel 1958). King Johan III released the deer at Ottenby in the southernmost part of the province Öland (an island in the Baltic Sea (Appendix 1)), where a 4.5 km long wall later was built to hinder a northward spread (Ramel 1958, Carlström & Nyman 2005). Fallow deer were then introduced at several larger estates in the

southern third of Sweden, where they were kept in enclosures. At royal estates enclosures could be large, e.g. at Omberg in the province Östergötland there was a royal enclosure of 3 000 ha. Generally, however, enclosures were relatively small and often set up close to the main buildings. The keeping of deer was probably a status symbol, but these deer enclosures did also secure access to hunting opportunities as well as meat. The enclosures protected the deer from predation and poaching, but did also protect crops from deer damage. The possibility to watch deer offered a pastime, and deer grazing helped keeping the close surroundings to the main buildings open (Ramel 1958, Carlström & Nyman 2005).

1.2.2 Distribution of fallow deer from the 19th century to present

Free-living populations of fallow deer were probably not established until during the 19th century, and then first in the southernmost province Skåne (Carlström & Nyman 2005). In the 1950s wild populations were found in the provinces Skåne, Västergötland, Småland, Närke, Östergötland, Södermanland, Västmanland, and Uppland (Figure 4). These populations mainly emanated from the old enclosures at the large estates, but there had also been several subsequent releases during the first half of the 20th century (Ramel 1958). However, establishments of enclosures inhabiting fallow deer have continued during the rest of the 20th century and in the 21st century, and escapes of fallow deer from enclosures have occurred on several occasions in different provinces (Laikre & Palmé 2005), also in provinces outside the former establishments, e.g. in Västerbotten, Dalarna, and Gotland (Jakt & Jägare 2007, Björklund 2013, Fredriksson 2023).

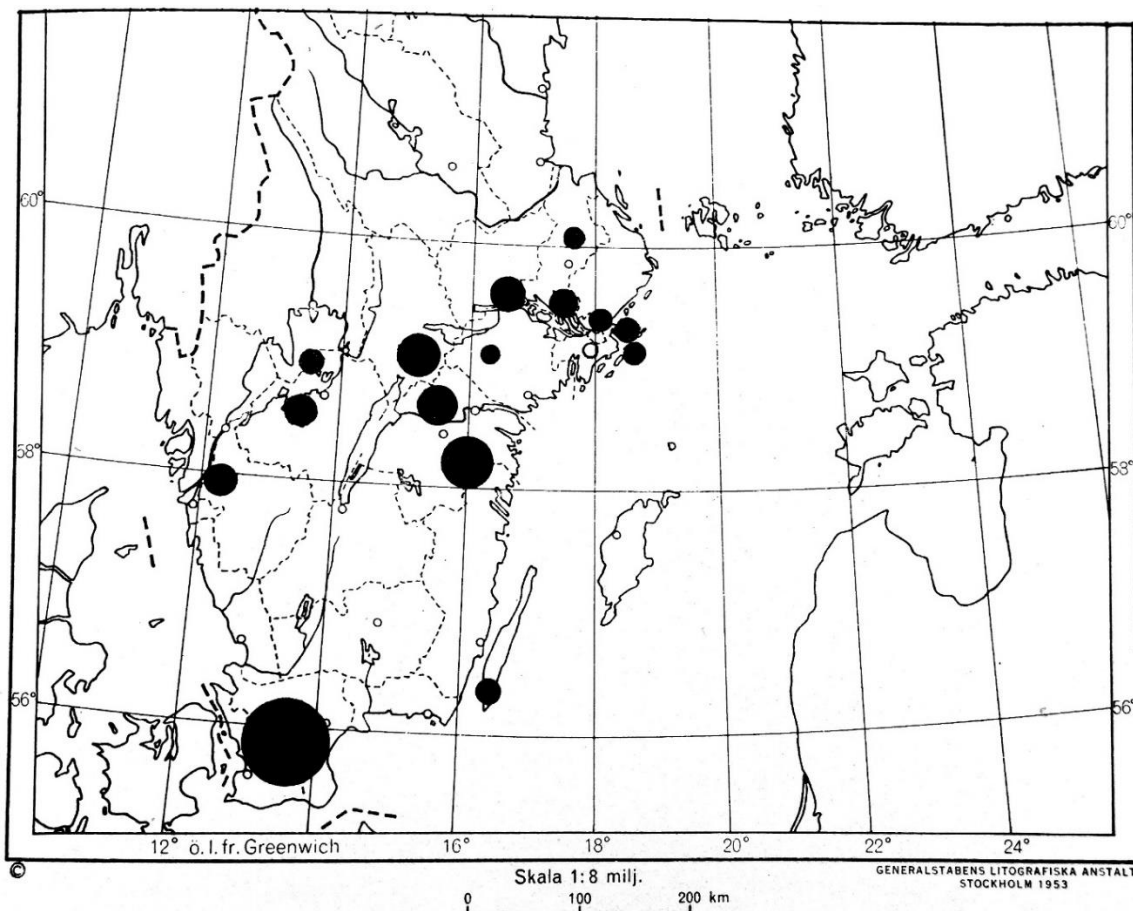


Figure 4. Fallow deer populations in Sweden 1958 (from Ramel 1958).

The national hunting bag of fallow deer increased slowly for the major part of the 20th century. From 200 - 300 deer during the 1940s to 2 000 - 3 500 in the beginning of the 1990s (Figure 5). However, from the mid-1990s a steep increase has been observed. Between 1990 and 2015 the harvest showed an exponential growth with an average annual growth rate of 12 % and a doubling time of six years (Svenska Jägareförbundet 2017). In 1995 the annual harvest was 5 000. For the hunting seasons 2020/2021 and 2021/2022, the harvest exceeded 70 000 deer (Figure 5).

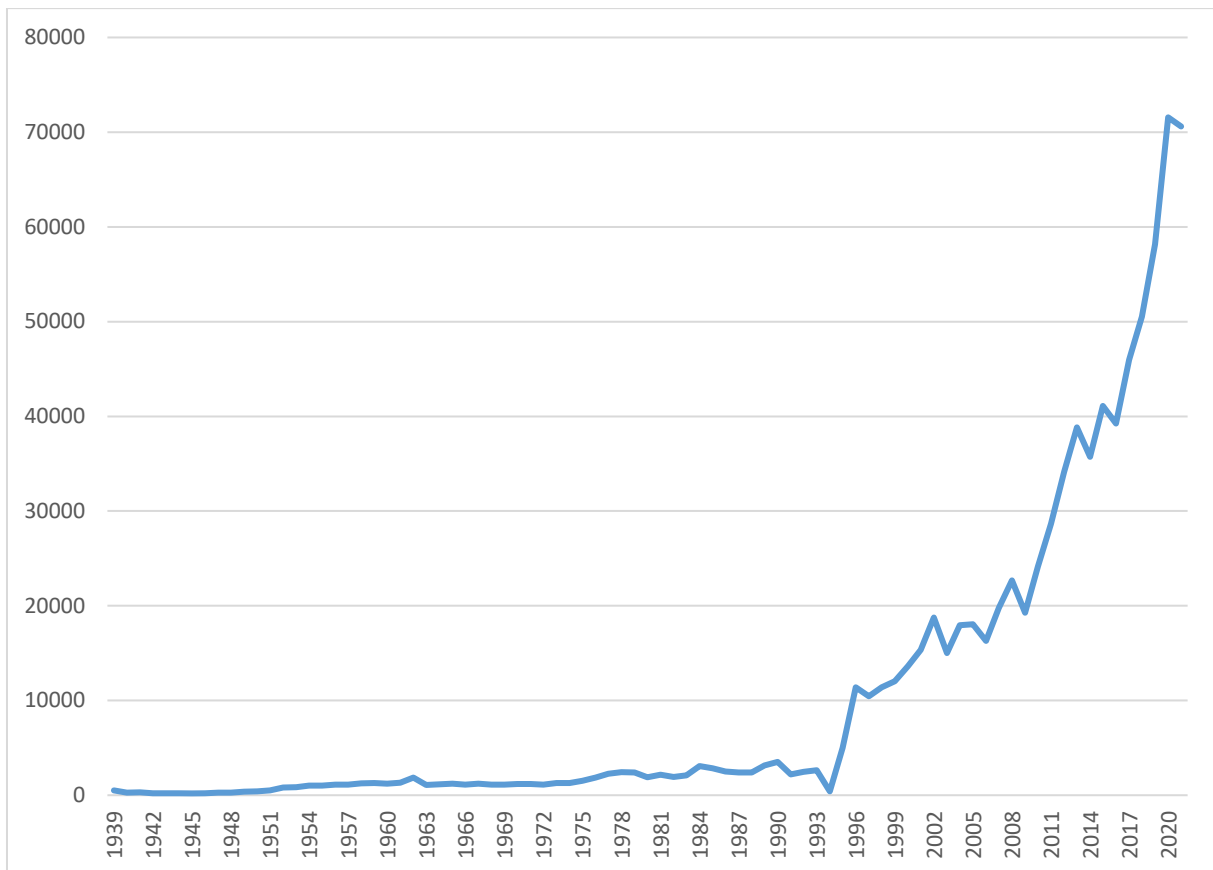


Figure 5. Fallow deer harvest in Sweden 1939 - 2021 (Viltdata.se, The Swedish Association for Hunting and Wildlife Management, data downloaded 2023-11-27).

Fallow deer has now a wide spread in the southern third of Sweden, with the strongest populations in the administrative counties (Appendix 2) of Skåne, Östergötland, Södermanland, Västra Götaland, Örebro, Kalmar, and Stockholm (Figure 6). The former distribution with distinct local establishments at larger estates, has changed. There are still high densities in the old fallow deer estates, but the species has expanded into new areas (Svenska Jägareförbundet 2017), and may occur in high densities also in areas where they were absent or rare just 20 – 30 years ago.

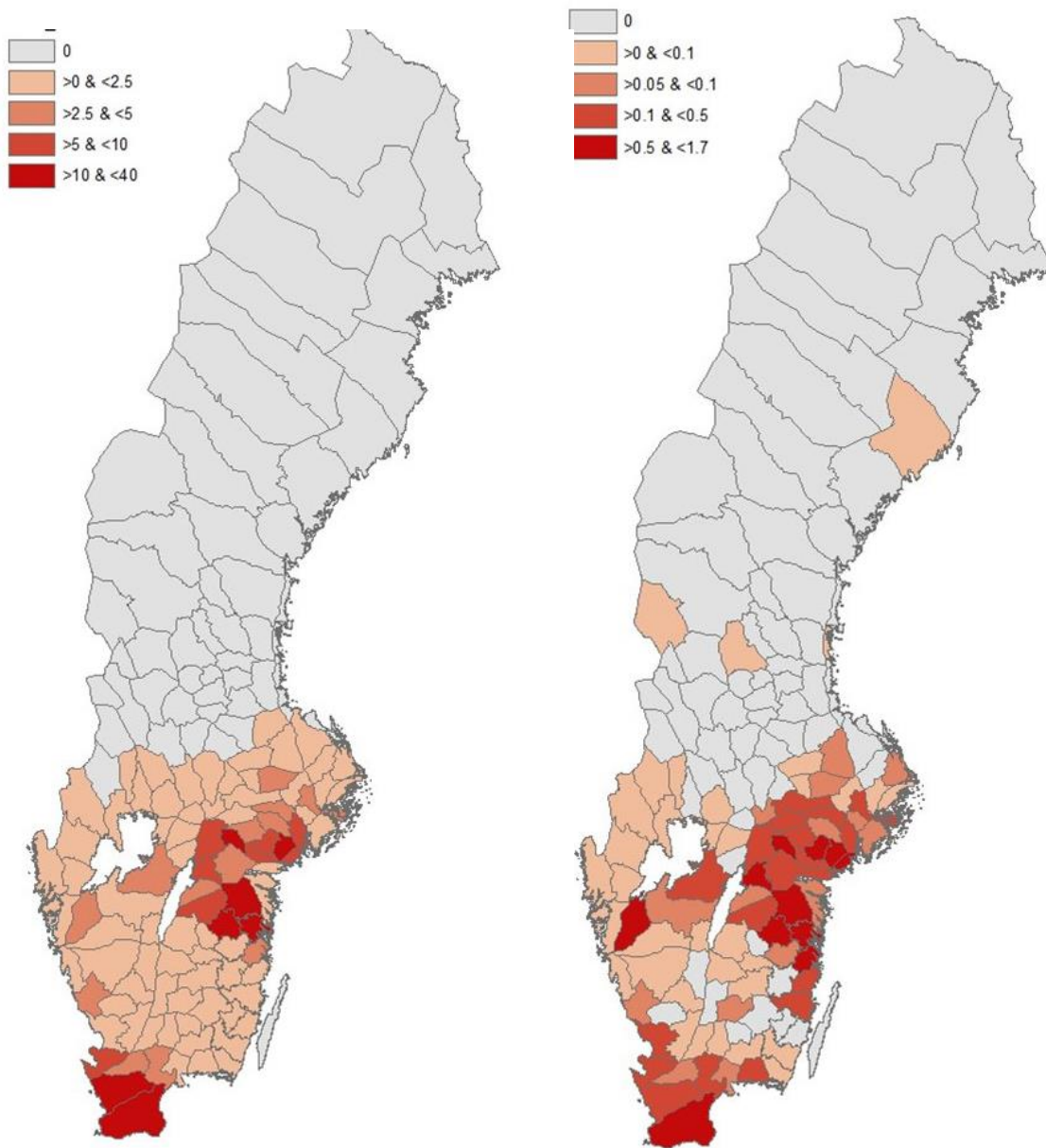


Figure 6. Fallow deer harvest (left), and number of traffic collisions involving fallow deer (right) in Sweden for the hunting season 2015/2016 (deer/1 000 ha). (From Jarnemo et al. 2018.)

1.3 Hunting legislations of red deer

1.3.1 Hunting legislations of red deer in Sweden outside Skåne

In administrative counties with red deer occurrence, the County Administrative Board shall determine overall aims for the management of red deer within the county (Naturvårdsverket 2011). When setting these aims, the County Administrative Board shall confer with landowner and hunters' organizations. Red deer are managed in red deer management units (the Swedish legal term: Kronhjortsskötselområden). The County Administrative Board decides a minimum size needed in order form a red deer management area. The general rule is

that a management unit should have a size and a hunting unit distribution that enables the management of a local red deer population within the management unit.

Hunting units apply to the County Administrative Board for the registration of a red deer management unit. The application must contain 1) a management plan, 2) a presentation of the included hunting units, and 3) a confirmation that the proprietors of hunting rights consent to the registration. The County Administrative Board have the possibility to add further requirements regarding the contents of an application. The County Administrative Board shall regularly, and at least every third year, follow up and audit the management plans, and when needed, take necessary actions.

The plan for a management unit should contain the following information:

- The long-term aim for the red deer population within the unit.
- Planned annual harvest.
- Measures taken to decrease damage to crops and forest plantations.
- Measures taken to decrease the risk for traffic collisions involving red deer.

The plan shall be revised every third year and sent to the County Administrative Board in due time before the start of the hunting season. Any changes of the delineation of the management unit shall be declared to the County Administrative Board.

For hunting units not registered in a red deer management unit, only calves are allowed to shoot. The hunting season for un-registered hunting units is 16 August – 31 January.

In red deer management units, females and calves are allowed 16 August – 28 (29) February. During 16 August – 30 September and 1 – 28 (29) February only by using sit-and-wait or stalking methods. Males are allowed 8 October – 31 January. The use of dogs is allowed 1 October – 31 January. (See also Appendix 3.).

In order to prevent direct damage on crops and on stems (from bark stripping) protective shooting of calves is allowed 1 July – 15 April.

1.3.2 The basis for the system of Red deer management units

As a result of increasing ungulate populations and increasing ungulate damage on crops and forest plantations, a general open hunting season as well as a prolonged hunting season on red deer was introduced in 1991. The idea was that management should aim for a balance between population densities and damage levels on crops, forest plantations, and horticulture, and to minimize deer – traffic collisions. Hunters and landowners should take a greater responsibility to achieve these goals. The shooting fee for red deer was removed, and the possibility to apply for compensation for damage caused by red deer was withdrawn (Regeringen 1991, Naturvårdsverket 2015a,b).

When the Habitats Directive was incorporated in the hunting regulations 1998 (Svensk Författningssamling 1998:1000), the general open hunting season was replaced by the system with Red deer management units (Naturvårdsverket 2015a,b). However, there was no enquiry or preparatory work before the introduction of the Red deer management units, and in 2015 The National Environmental Agency, concluded that a comprehensive view and necessary tools for an efficient management were missing (Naturvårdsverket 2015a,b).

1.3.3 Hunting legislations of red deer in Skåne

The management of red deer in Skåne differs from the rest of Sweden. One reason for this is to preserve the original nominate subspecies of red deer that prevails in southern Skåne. The open landscape dominated by agriculture, also motivates a different management system. A high hunting pressure in the agricultural landscape results in that red deer spend more time in dense forest plantations with increased damage risk on trees. The open landscape makes it easier to locate and hunt red deer, further advocating the need for a regulated hunting system. The management of red deer in Skåne has been recognized as well-functioning (Naturvårdsverket 2023).

In the range of the nominate subspecies (roughly the southeastern third of Skåne) red deer are managed in 'Red deer areas' (Swedish legal term: Kronhjortsområden) (Naturvårdsverket 2011). In order to shoot red deer in Red deer areas, hunting units must yearly apply for a license on red deer at the County Administrative Board. An approved license contains a specified number of deer in the following categories: calves, hinds, stags with a maximum of 5 tines, stags with a maximum of 8 tines, and deer-free-of-choice. The last category is thus needed to shoot a large-antlered stag. A hind license can be utilized to instead shooting a calf. A stag license with a maximum of 5 or 8 tines can be utilized to instead shooting a hind or a calf. However, the County Administrative Board can withdraw the possibility to change from a hind to a calf, or from a stag to a hind or a calf, if this is needed to reach management goals.

To get a license a minimum size of the hunting unit of 200 ha is required. It is possible to join neighbouring hunting units and form larger license applications, both to reach 200 ha, but also to create even larger sizes of the hunting unit in order to increase the number of deer obtained, or to increase the chances of obtaining stags and deer-free-of-choice. The County Administrative Board takes a positive view on hunting units joining and forming larger units, and promotes this by increasing the chances to obtain male licenses and deer-free-of-choice.

The approved number of deer in a license is based on hunting unit size, local red deer occurrence, ratio forest/agricultural land, damage situation, and current situation in the total population. The approved licenses are sent out to the hunting units in early summer together with an information letter, and the hunting units then have the possibility to reply and comment or argue for changes of the approved license.

When a hunting unit have shot the full license quota, it is possible to apply for an extra license during the hunting season. This gives the possibility to adapt harvest to the current local situation regarding deer movements and damage. As monitoring is conducted during the rut, i.e. post the handing out of licenses but pre-harvest, up-to-date information of population changes can be taken into account when handing out extra licenses.

The County Administrative Board in Skåne can set the hunting season in Red deer areas to one or more periods during 8 October to 31 January (Prior to 2021 the hunting season started on the second Monday in October.). So far, the season has been set to 8 October to 31 January. (See also Appendix 3.).

Harvest must be reported to the County Administrative Board at the latest at 10 February. If a hunting unit fail to report harvest, they will not get a license for the next season.

The Red deer areas are coordinated in a management area (Jarnemo & Carlsson 2015) that covers 260 000 ha. A total of approximately 180 hunting units, varying in size from 200 – 8 500 ha, apply annually for a red deer license.

Outside the Red deer areas – roughly the northwestern two thirds of Skåne – there is a general open season with no needs for permits and without any regulations regarding number or category of deer harvested. There are two reasons for the open season outside the Red deer areas. One is to decrease the risk of migratory deer from the north to enter the nominate subspecies population, and another reason is that red deer are unwanted in the northern more forested parts of Skåne due to the risk of damage on forest plantations. The hunting season outside the Red deer areas is 8 October to 31 January.

In order to prevent direct damage on crops and damage on stems (from bark stripping) protective shooting of calves is allowed 1 July – 15 April.

1.3.4 The basis for the license management of red deer in Skåne

Since the early to mid 1900s the conservation perspective has had a strong impact on the management of red deer in Skåne. During the first half of the 20th century main focus was to save the original Swedish red deer population from extermination, but from the 1970s the management also started to focus on population composition. A growing insight of that adult males were largely underrepresented in the population, led to preservation efforts of large-antlered males. In the 21st century the conservation perspective is fundamental in the management in Skåne. In a regional management plan (Jarnemo & Carlsson 2015) established by the County Administrative Board, it is stated that management shall secure a long-term viable population regarding both size and composition of the population. The population should also allow an annual sustainable harvest and be balanced with regard to damage in forestry and agriculture. The aim is a pre-harvest population size of 3 000 deer, including an approximately even sex ratio and a proportion of mature males (age 6-14 years) of 10 %.

The license system and its categories have been constructed to be able to fulfil the goals regarding population size and composition. By adjusting assigned licenses in the different categories, it shall be possible to steer the population in the desired direction regarding population size and age and sex ratios.

The distribution of calf licenses is generous. In natural ungulate populations juvenile mortality is generally higher and more variable compared to adult mortality (Guinness et al. 1978; Linnel et al. 1995, Jarnemo 2004). Calf survival has a lower impact on population growth rate and on variations in population size than survival of adult females (Albon et al. 2000, Gaillard et al. 2000).

Hind licenses are used to steer population density in desired direction. In local areas where density, and perhaps damage, is considered too high, the distribution of hind licenses is generous, whereas in areas with few hinds, or where the population has undergone an undesired decrease, the distribution of hind licenses may be reduced. The possibility to utilize a hind license to instead shoot a calf, give hunting units some latitude to adapt harvest to the local red deer situation. However, if the local density is considered too high, and if hunting units still harvest too few hinds, the County Administrative Board can remove the possibility to shoot calves on hind licenses.

Intensive trophy hunting can lead to an over-harvest of males (Clutton-Brock & Albon 1989, Buckland et al. 1996, Milner-Gulland et al. 2004). In combination with a reluctance to harvest females, this leads to populations with a sex ratio highly skewed towards females and with a low average age for males (Beddington 1974, Ginsberg & Milner-Gulland 1994, Langvatn & Loison 1999), with possible negative effects on population dynamics, (Mysterud et al. 2002) and a potential for high population growth (Caughley 1977).

Red deer males reach their full body-mass at an age of six to eight years and peak in strength, dominance during rut, and in antler size at ten to fourteen years of age (Langvatn & Albon 1986; Wagenknecht 1986; Meisingset & Langvatn 2000). Mature males play an important role during the rut. The roaring of mature males triggers the onset of the oestrous in the females (McComb 1987), and the females select those males that roar most frequently, which also are the males that are the most successful in fights and in reproductive performance (McComb 1991). Red deer females seem to want to avoid mating with males younger than five years, and can postpone mating in the absence of mature males (Clutton-Brock et al. 1982). Females also seek the harems of dominant males to avoid stressful harassment from young males. Standing in a strong male's harem, the females get a less stressful rut and a better preparation before winter and the next gestation period (Carranza & Valencia 1999). A well-balanced age and sex ratio is thus desirable also from a conservation point of view (Ginsberg and Milner-Gulland 1994).

Regarding males, it is desirable to have a harvest of both young individuals as well as of older individuals. However, a single male license category would probably, or even likely, lead to that too many large-antlered males would be shot, resulting in a population with a low average age of males and few mature males. In order to enable a harvest of younger males, a sustainable harvest of mature males, and a possibility to implement a selective harvest, there are three license categories.

Male licenses of maximum 5 tines, enables to shoot yearlings with typically single spikes (2 tines), but also males two-three years old with 4-5 tines. The maximum of 5 tines is based on the idea that males two years old, should have at least 6 tines.

The purpose of the category maximum 8 tines, is primarily to shoot males five years and older, but with poor antler development and only 6-8 tines. The category also allows old males showing a strong decline in antler size and reduction in number of tines to be shot.

A male license of a maximum of 5 or 8 tines can be utilized to shoot a hind or a calf, giving the hunting unit a latitude to adapt harvest to the local current situation.

The distribution of the license category deer-free-of-choice is restricted and carefully adapted to the ratio mature males in the population. Before the hunting season 2023/2024, 38 % of the hunting units had the possibility to shoot a deer-free-of-choice.

Males generally have larger home ranges than females (Jarnemo et al. 2023), and can also perform seasonal migrations between a rut area and a winter-summer area (Jarnemo 2008; Kropil et al. 2015, Jarnemo et al. 2023), which could further increase a male overharvest as they face different hunting regimes. To decrease the risk of overharvesting of males, it is therefore important to coordinate management and male harvest between rut areas and male winter areas (Jarnemo 2008, Kropil et al. 2015, Meisingset et al. 2018, Fattorini et al. 2020,

Jarnemo et al. 2023). In the management area, the distribution of male licenses, and especially the category deer-free-of-choice, is coordinated between rut areas and male winter areas. The latter have been mapped since the 1960s and 1970s and are thus well known (Jarnemo 2008). It is often possible to supply hunting units, both in rut areas and in winter areas, with photos from the rut monitoring of old males that can be recommended to be harvested.

1.4 Hunting legislations of fallow deer

1.4.1 General open hunting season

There is a general open hunting season for fallow deer in Sweden, i.e. there is not a need for any special permits, and there are no regulations regarding size of a hunting unit or regarding number of deer that can be shot in a hunting unit (Jaktförordningen 1987:905). However, the number of harvested deer should be adjusted in accordance with deer occurrence.

The hunting periods for fallow deer in Sweden were modified in 2021. Antlered males and calves are allowed during 1 – 30 September, but only by using sit-and-wait or stalking methods. Before 2021 only antlered males were allowed in September.

All animals are allowed during 1 – 20 October, and 16 November – 28 (29) February. The break between 21 October and 15 November is due to the rutting period, but the break only concerns adult males as females and calves are allowed 21 October – 15 November. From 2021 females and calves are also allowed 1 – 31 March (sit-and-wait or stalking methods). The use of dogs is allowed 1 October – 31 January.

In order to prevent direct damage on crops protective shooting of calves is allowed July – 15 April.

1.4.2 The basis for the management of fallow deer in Sweden

The management of fallow deer in Sweden has not been subject to any thorough investigation or evaluation as has been the case for moose and for red deer. There are probably different reasons for this and to why fallow deer harvest is just regulated by the length of the hunting season and not subject to a regulated and planned management similar to the managements of moose and red deer.

Moose and red deer are larger and individual animals represent a higher economic value from a meat perspective. As opposed to fallow deer, moose and red deer are native species, which may have impacted management perspectives. Both moose and red deer populations declined to very low numbers in the 1800s and in the beginning of the 1900s, especially red deer were close to extinction (Ahlen 1965a), which arouse the need for protection and hunting regulations (Danell et al. 2016). Fallow deer in the 1800s, were still largely found in enclosures at large estates (Ramel 1958). And for the major part of the 1900s, the species still had a highly local distribution confined to larger estates where the founding populations could be tracked back to old deer parks or early releases (Carlström & Nyman 2005). It is only during the last 10-15 years, with the exponential increase of fallow deer numbers (Svenska Jägareförbundet 2017), that a discussion about fallow deer numbers and management has aroused, and then foremost on local and regional levels, resulting in a prolonged hunting season, in an increase of protective shooting permits, in proclaimed general protective shootings, and in voluntary fallow deer management units.

1.5 Management system for moose in Sweden

In order to evaluate the Red deer management units, it is of interest to compare them with Moose (*Alces alces*) management units. These have a similar construction as for red deer, but there are also important differences.

In 2012 a new moose management system was introduced in Sweden. The aim with the new management system was that it must be anchored locally, ecosystem-based, and adaptive, creating a moose population of high quality in balance with regard to forage availability, damage on forest plantations, biodiversity, traffic accidents, and predators (Regeringen 2010, Naturvårdsverket 2011). To be able to reach these goals, the moose management was organized in different levels, where the County Administrative Board sets overall guidelines for the management of moose on the county level, Moose management groups on the ecosystem level, and Moose management units on the local level (Figure 7).

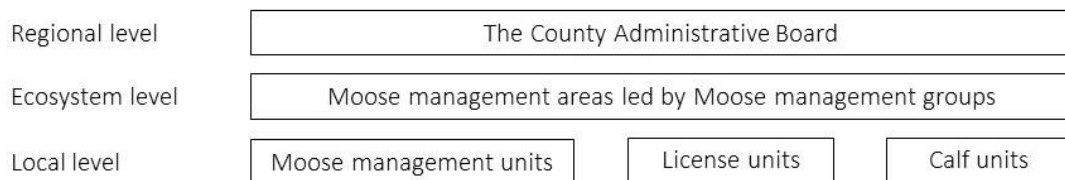


Figure 7. Organization of moose management on regional, ecosystem and local levels in administrative counties in Sweden.

Moose can be hunted within three different types of hunting units, where voluntary cooperation in Moose management units is the recommended and presupposed dominant form of hunting.

For those that cannot or do not want to participate in a Moose management unit, it is possible to form a license unit. The unit must be large enough to allow to shoot at least one calf annually. The unit gets a specified number of calves and adult moose from the County Administrative Board. The number of moose given is based on the size and location of the license unit. As an example, in Halland the minimum size required to obtain a calf varies between 400 and 550 ha for the season 2023/2024, and to obtain a calf and an adult the size varies between 750 and 1 650 ha (The County Administrative Board in Halland 2023).

For hunting units (calf units in Figure 7) that do not fulfil the requirements for license units, and that do not participate in Moose management units, it is possible to shoot calves during the first five days of the moose hunting season.

The hunting season for Moose management units and license units in northern Sweden is 1 September – 31 January, and in southern Sweden 8 October – 31 January.

The administrative counties are divided into Moose management areas (Figure 8). These correspond to the ecosystem-level in the moose management. The guideline is that Moose management areas in southern Sweden should have a size of at least 50 000 ha, and in northern Sweden of at least 100 000 ha (Naturvårdsverket 2011).

Each Moose management area is led by a Moose management group where three delegates represent landowners and three delegates represent hunters. Chairperson with casting vote is one of the landowner delegates. The moose management group has the following tasks:

- Produce a management plan for the Moose management area with recommendations and guidelines.
- Suggest monitoring of moose and analyse data from monitoring.
- Consider forage availability and damage levels in forest plantations.
- Consider predation levels.
- Confer with Moose management units.
- Audit the moose management plans of Moose management units.
- Recommend required minimum sizes of license units.

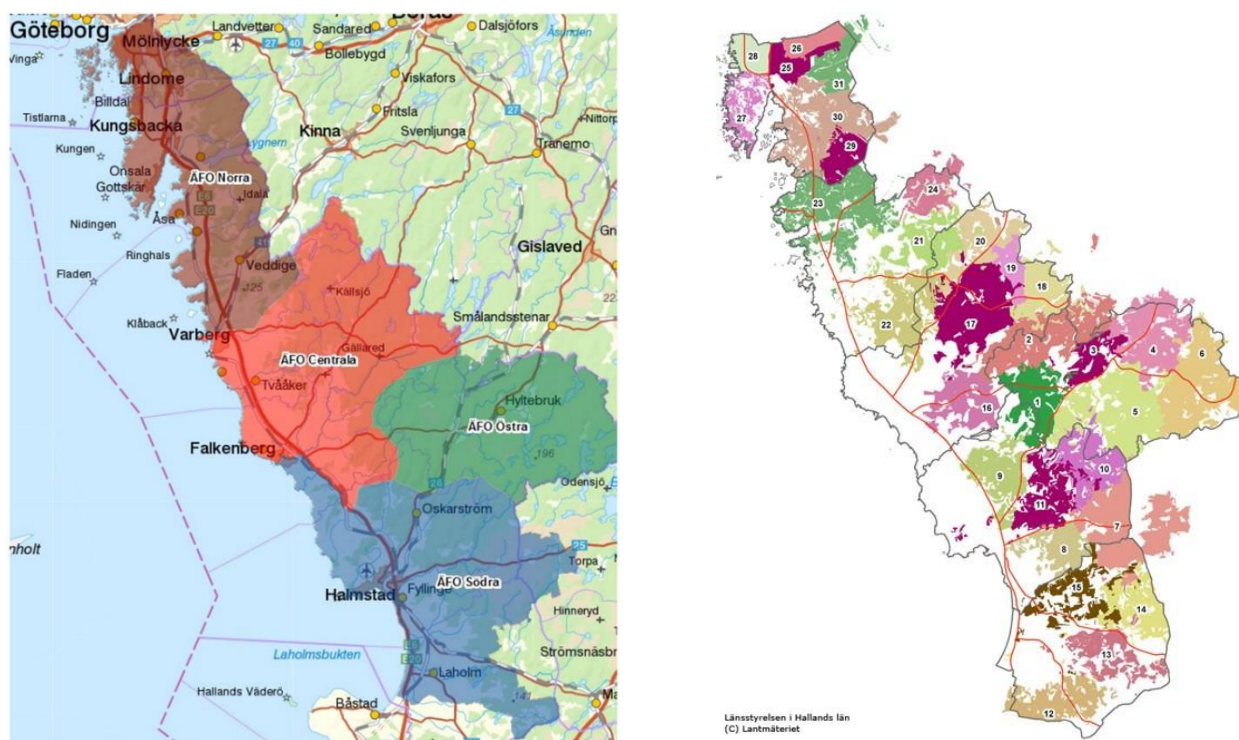


Figure 8. Moose management areas (left) and Moose management units (right) in the administrative county of Halland (from the County Administrative Board of Halland).

To register a Moose management unit at the County Administrative Board, the unit should be able to sustainably harvest 10 adult moose per year. However, under special circumstances, it may be possible to register a unit, even below an annual harvest of 10 adult moose (Naturvårdsverket 2011). The unit should be geographically coherent and encompass the same moose population.

The Moose management unit shall produce a three-year management plan that must be approved by the County Administrative Board. The plan shall contribute to an adaptive management and be in line with the goals in the plan for the Moose management area. The Moose management unit shall confer with the Moose management group when producing their plan. The plan for the Moose management unit shall always contain:

1. A description of the long-term goal for the moose management in the unit.
2. A follow-up of the preceding plan.
3. An estimation of moose occurrence within the unit, divided into males, females, and calves.
4. A description of available moose forage within the unit, and what measures that are taken to counteract moose damage to crops, forest plantations, and biodiversity.
5. A description of the measures that can be taken if objectives are not achieved.
6. A presentation of planned monitoring actions.
7. A planned annual harvest of males, females, and calves.
8. The approval of the plan by the Moose management group.

At least once a year, the Moose management unit shall do a follow-up of the plan, and if necessary, take action and suggest changes to be approved by the County Administrative Board.

The County Administrative Board can unregister a Moose management unit if the management considerably deviates from the plan. An annual harvest that deviates more than 10 % from the plan regarding total number of moose, ratio adult moose and calves, or sex ratio among adult moose, should be considered as a considerable deviation if it happens more than once during a three-year period. Other reasons for deregistration may be failing in conducting monitoring or not attending consultation with the Moose management group (Naturvårdsverket 2011).

Since the new moose management was introduced, the population has decreased. In 2013/2014, 95 000 moose were harvested, in 2022/2023, 63 000 (Viltdata.se, The Swedish Association for Hunting and Wildlife Management).

1.6 Experiences and outcomes of management systems

1.6.1 Red deer

1.6.1.1 Red deer management units in Sweden

The Swedish Environmental Protection Agency (EPA) evaluated the management of red deer in Sweden in 2015 (Naturvårdsverket 2015a). A general conclusion was that the red deer management to a large extent was facing similar problems as the management of moose did earlier and which led to a reformation of the moose management system in 2012 (Norrfolk 2009, Regeringen 2010). A comprehensive view on management was missing, and there was no common principles or a clear vision for the management of red deer (Naturvårdsverket 2015a,b). However, so far EPA has not introduced any changes in the management system of red deer and the overall problems seem to remain the same, although there are also improvements, mainly due to active County Administrative Boards.

At the time of the EPA report several counties did not have a vision or a plan for management of red deer in the county, although there were counties where guidelines were underway. The knowledge of the distribution and densities of red deer in the counties was poor. The lack of directed funding for the administration of red deer management (as opposed to moose management), made it difficult for the wildlife administrators to devote as much time to red deer management as needed. Insufficient funding made it difficult to pursue an active management, to create conditions for collaboration and to increase knowledge among hunters and landowners. Compared to moose, fallow deer, and wild boar, the wildlife administrators at the County Administrative Boards, devoted relatively little time to red deer.

Regarding the Red deer management units, several deficits that aggravates an expedient red deer management can be listed (Naturvårdsverket 2015a).

Too small: The management units are generally too small to be able to manage a red deer population within its borders. In general, The County Administrative Boards demands at least 10 000 ha for the registration of a Red deer management unit, and in 2015 the average size was 17 500 ha, with generally larger units in the north of Sweden and smaller in the south. However, red deer males perform seasonally migrations over distances of 10-45 km, suggesting that management needs to be coordinated over at least 50 000 to 100 000 ha in order to be able to reach management goals regarding age and sex ratios (Jarnemo 2008, Kropil et al. 2015, Meisingset et al. 2018, Jarnemo et al. 2023). Females are in general more stationary, at least in landscapes dominated by forest (Jarnemo et al. 2023), and the sizes of the Red deer management units are probably in most cases large enough to manage females and calves.

In the Kolmården area, about 100 km southwest Stockholm on the border between Södermanland and Östergötland, six Red deer management units had an alternative solution to the problem of too small management units (Jarnemo 2014). In the area there were landowners and farmers complaining over severe damage on crops and that deer numbers were too high. Simultaneously other landowners and wildlife managers were of the opinion that the male ratio was too low and that there were too few mature males. The six management units, covering 32 000 ha, formed a council where management issues across the borders of the management units could be discussed and common guidelines regarding harvest could be agreed. The overall goals were to lower local population density where needed, to even out sex ratio, and to increase number of mature males. The single management units could themselves decide harvest of females and calves, but number of males to be harvested were agreed jointly.

Lack of population data: There is a strong need for reliable monitoring methods. It seems common that Red deer management units do not monitor red deer, or that they use methods giving unreliable or unusable data.

Lack of knowledge about red deer: An underlying and most likely fundamental problem for the work in Red deer management units, is a general poor knowledge about red deer ecology and how to manage and hunt the species (Naturvårdsverket 2015a). Swedish hunters and landowners have generally little experience of red deer compared to for example moose. Furthermore, when the new moose management system was introduced 2012, an educational package of courses, meetings, manuals, fact sheets, and information was produced to further enhance knowledge about moose and moose management among hunters and landowners. A

correspondingly educational package regarding red deer is still missing. The deficits in knowledge are likely to affect management in several ways.

Low quality of plans: The EPA report (Naturvårdsverket 2015a) found that the contents of the plans in the Red deer management units were of low quality, and when the plans were revised, the revision often consisted only of a modification of the planned harvest. A contributory cause for this, alongside the lack of knowledge, is probably that there aren't any detailed regulations of what a red deer management plan should contain, whereas for moose, the necessary contents are described in detail. Red deer management units thus need support when producing their plans.

Inefficient in reaching goals: Management units are inefficient in reaching the goals in the plan. This can partly be related to the low quality of the plans, but also that the County Administrative Board have small opportunities to have an impact on the plan. Another cause is unrealistic goals that do not harmonize with the actual red deer population within the management unit, e.g. that the population size is overestimated and even that the planned harvest exceeds the number of deer in the area. In the absence of reliable monitoring data, the planned harvest risks being based on opinions and guessing. Planned harvest and conducted harvest may thus differentiate. It may be that the unit is far from reaching the planned harvest, but it may also be that the performed harvest varies for different deer categories. In my experience, a seemingly common case is a plan where the expressed main goals are to lower population density, create a more even sex ratio, and increase the ratio mature males. However, in the planned harvest the number of males, and especially large-antlered males, that are allowed to shoot, are often too high in relation to the stated goals. When the harvest has been conducted, it is not unusual that if there is a category where the planned harvest hasn't been reached, it is the hind category. If there is a category where executed harvest has exceeded the planned harvest, it is the male category. Goals, planned harvest and executed harvest do not harmonize (Jarnemo 2014). The management units have difficulties to restrain the desire among their members to shoot trophy animals. When Red deer management units contact me for lectures on red deer ecology and management, they have generally two main requests. The first is "You need to come and teach us about red deer ecology and how to manage them!", and the other request is "You must come and explain to the members why they cannot shoot that many (large) males/all males they see!".

Inefficient distribution of hunting quotas: Yet another reason to why the execution of the plans is insufficient, may be how the deer planned to be harvested are distributed among hunting units within the management unit. There is a thinking, probably derived from moose management, that the distribution of deer should be 'fair', i.e. that the number of deer to be shot should be distributed equally among the hunting units and that the quota should be based on the size of each hunting unit. However, as red deer often have a distribution that can show large variations within a Red deer management unit, a 'fair' distribution of hunting quotas, may result in that hunting units with few or no red deer do not fill their quota, whereas hunting units with a high deer density have hunting quotas that are too small. The outcome for the management unit is that the planned harvest is not reached.

Ineffective hunting methods: The inexperience among Swedish hunters concerning red deer also leads to the use of hunting methods and hunting dogs poorly adapted to red deer (Jarnemo & Wikenros 2014). Moreover, hunts may not be directed primarily at red deer, but instead hunters shoot red deer if they get the chance when hunting moose or other ungulates.

The outcome is that the hunt for red deer is ineffective, thus adding another cause to why management units fail to reach planned harvest.

The combination of a lack of knowledge, a poor insight into problems, a lack of reliable population data, and the use of ineffective hunting methods, results in an inefficient management.

The main conclusion from the 2015 EPA evaluation was that Red deer management units should be incorporated in the same system as the moose management (Naturvårdsverket 2015a,b). To date, the Red deer management units have not been incorporated in the same judicial framework as the moose management.

The management units of moose and of red deer have a similar construction. However, the Moose management units have a more well-defined work process. They must monitor the population, there are detailed instructions for what the management plans must contain, there are guidelines from the Moose management group to follow, and the plans are scrutinized by the Moose management group and the County Administrative Board. Plans of low quality or where goals and planned measures do not harmonize are not approved, and the management units have a pressure to follow the management plans. This together with that Swedish hunters and landowners have more experience and a better knowledge of moose, put the Moose management units in a better position for a successful management, compared to the Red deer management units.

Since the EPA report in 2015, there seem to have been some progress. It seems more common that the County Administrative Boards have set guidelines for the management of red deer, or alternatively, that they have a joint management plan for ungulates. In many counties Moose management units are advised by the County Administrative Board to also register a Red deer management unit, and management and administration of the two species are in practice often coordinated. In some counties the Moose management groups examine and comment also the red management plans. There is still a need for an increased knowledge about red deer ecology and management, but there is also a strong interest among hunters and Red deer management units to learn more.

1.6.1.2 Red deer license management in Skåne

The population within the management area of the nominate subspecies is believed to have reached the goal of 3 000 deer pre-harvest. For the latest five years the annual monitoring as well as the annual harvest suggest a stable population size.

The annual monitoring during the rut shows an average adult sex ratio of 1.4 hinds/males. However, it is possible that males are underestimated in the survey due to that females are generally more stationary on the rutting grounds throughout the rut, whereas males, seasonally migrating, arrive and depart at the rutting grounds at different times, and can move between different rutting grounds within the same rutting season (Jarnemo 2008, 2011, Jarnemo et al. 2017).

The goal of a ratio of mature males (≥ 6 years old) of at least 10 % was reached in 2006 and has been maintained since. Both the annual monitoring and an annual exhibition of trophies post hunting season, indicate that it is common with stags 10-14 years old in the population.

The license categories of males with maximum 5 or 8 tines, and the deer-free-of-choice, allows a harvest of males in all age classes. The category of maximum 5 tines is often utilized to harvest yearling males, but the hunters have also learnt that shooting a male with 4 or 5 tines may be selectively preferable. The category of maximum 8 tines foremost aims at stags 5 years and older with only 8 tines. However, it seems more common that hunters principally want to maximize the number of tines, and rather than waiting for an older stag, they tend to shoot younger stags with 7-8 tines. The hope is to change this by continuing to provide information to hunters about selective hunting.

During the 1990s and the first years of the 2000s, the distribution of the license category deer-free-of-choice was highly restrictive, in order to increase average age of males and the ratio of mature males. This led to a lot of complaints from hunting units. However, as the ratio of mature males, and also males at peak age, increased in the population, the distribution of the deer-free-of-choice could successively be increased, allowing more hunting units to have the chance to shoot a large trophy deer. The possibility to harvest a large trophy stag is highly appreciated, but hunters also frequently tell about how much they now appreciate the experience of seeing a bachelor group of large stags passing during a hunt.

The still restrictive distribution of the license category deer-free-of-choice seems to have yet another consequence. As there are few licenses allowing large stags to be shot, hunters can let a large but too young stag pass and instead wait for an older stag, as the risk that someone else will shoot the stag is rather small. In less regulated hunting systems, it is more likely that hunters will shoot the stag even if they think it is too young, as there is a higher risk that someone else will shoot the stag anyway.

The division of male categories into maximum 5 tines, maximum 8 tines, and deer-free-of-choice, was introduced in the late 1990s. Previously males with 8 – 12 tines had been protected, i.e. only males with less than 8 tines or more than 12 tines were allowed to be shot. However, these tine restrictions had unwanted consequences. The hunting pressure on young stags became too hard, and too few stags entered the 8 – 12 tines category. When a strong stag got more than 12 tines, he was subject to a high risk of being shot. The system thus favoured stags with a weak antler growth. Moreover, if there were stags of old age, with declining number of tines, these could not be shot if they got fewer than 13 tines. The experience from Skåne is that, rather than having a protected tine-interval, it is better to have a set hunting quota of a number of males divided into different tine-intervals, allowing a harvest of stags in all age classes.

The license system has thus proven to be effective in order to increase male ratio as well as the ratio of mature males. The system has also been efficient when it has been necessary to decrease local population density. By increasing the license quota of hinds, and perhaps also withdraw the possibility to utilize hind licenses to shoot calves, density has been decreased relatively fast in areas where landowners and hunting units have expressed a wish to lower damage levels and number of deer. It is, though, a lesson that a generous allocation of hind licenses may not be enough to increase female harvest. Even hunting units complaining over a too high population density, may be reluctant to harvest females and may utilize hind licenses to shoot calves. In these cases it has been necessary to withdraw the possibility to utilize hind licenses to shoot a calves. However, during the 2000s, it seems that hunters have been educated by the license system and learned that it is necessary to also shoot female red deer.

The possibility to join neighbouring hunting units and form larger license applications has shown an increased use during the 2000s. There are several license applications covering 1 000 – 4 000 ha that consist of many smaller hunting units that have joined in a common application. The carrot is partly to obtain a higher number of deer totally and more male licenses, but also to have a chance to obtain a deer-free-of-choice. From the side of the County Administrative Board it is easier to get an expedient management of the local population with fewer large applications than many small. It also seems that the number of complaints regarding damage, decreases when small hunting units in an area join in larger applications.

To get an understanding and an acceptance for the license management system, it has been important to continuously inform hunters and landowners about red deer ecology, management issues, and population changes. It is central to explain why these specific goals of the management have been chosen, why the license quotas contain the deer they do, and why male harvest needs to be restricted. Then there is generally a high acceptance of the management among hunters. An information letter is included when the license quota is sent out to the hunting units. The letter gives information about the basis for and the main aims of the management, but also about executed harvest previous season, observed population changes, and explanations to why license quotas may have been changed. The homepage of the County Administrative Board has information about legislation and how to apply, report etc., but there is also a thorough information text about red deer ecology and management. In spring the County Administrative Board, The Swedish Hunters and Wildlife Association in Skåne, and research (A. Jarnemo) arrange an annual red deer information day, presenting information on harvest, management issues, and red deer ecology. There is also an exhibition of the season's trophies that draws a lot of attention. During the day hunters and landowners can meet representatives for the County Administrative Board, The Swedish Hunters and Wildlife Association, and research, to ask questions and to discuss management.

1.6.1.3 General open season in Skåne

Outside the management area with the license regulated harvest, there is a general open season on red deer. Red deer exist in three – four areas in northern Skåne, but little is known about these populations. Despite that it is obligatory to report harvested red deer to the County Administrative Board, very few do. Information campaigns from the County Administrative Board have improved report frequency somewhat, but the number of unreported harvested deer is most likely much higher than the number of reported deer. Without hunting statistics and systematic surveys, the knowledge of the populations is poor. The number of deer is probably increasing, and the hunting pressure on stags seems to be high.

1.6.1.4 A voluntary red deer management unit

In an area northwest of the city Kristianstad in northeastern Skåne (i.e. in the area where there is a general open season) a voluntary management unit for red deer was established in 2005. One goal was to decrease deer in areas with high concentrations to decrease damage, and instead try to obtain a more even distribution of the deer over a larger area. Other goals were to get a more even sex ratio and increase number of mature males (T. Lundström personal communication, 10 Dec. 2023). Today the voluntary management unit consists of 40 hunting units and covers approximately 25 000 ha. In the central parts of the management unit member hunting units cover approximately 70-75 % of the land.

The population is surveyed through hunting observations during the first month of the hunting season. The management seems to have led to that the deer are more evenly distributed over the management unit. The number of males increases, although it takes time. It is, however, a problem that there are small hunting units that do not participate in the management unit, and that continues to shoot many males. These small hunting units often sustain their harvests by supplying a lot of feed to attract red deer and other ungulates to their grounds.

A positive experience is that the cooperation in the management unit has resulted in that hunters and landowners have obtained an increased knowledge about red deer and a more management-oriented awareness (T. Lundström personal communication 10 Dec. 2023).

1.6.2 Fallow deer

1.6.2.1 Probable causes for the increase in fallow deer numbers

Fallow deer numbers in Sweden have shown a large increase in the 21st century, from a harvest of 12 000 deer in 1999 to a harvest of more than 70 000 in 2021. The species has also expanded its range, and is no longer confined to the larger estates where fallow deer once were held in enclosures or were released.

The population increase and expansion is a well-known, common, and expected outcome in the absence of harvest regulations and a planned, coordinated management, thus following the pattern of the tragedy of the commons (Hardin 1968). The consequences are generally an over-harvest of males and a corresponding low harvest of females, resulting in a female-biased population with a low male ratio and a low average age of males (Beddington 1974, Ginsberg & Milner-Gulland 1994, Langvatn & Loison 1999, Solberg et al. 2000, Festa-Bianchet 2003, Coltman et al. 2003, Garel et al. 2007, Sunde & Haugaard 2014, Torres-Porras et al. 2014).

In a female-biased population, a large portion of the adults give birth to a calf each year, provided that there are enough males to service the females during the rut. This induces a potentially high growth rate in the population (Caughley 1977). On the other hand, a low male ratio, a reduced mean age of males, and a lack of mature males, may delay birth dates, reduce birth synchrony, delay body mass development, and alter offspring sex ratios (Milner et al. 2007).

The main explanation for the increasing population size is most likely a harvest below population growth, and especially a low harvest of females. However, the population has probably also been added animals by late releases and escapes from enclosures during the 21st century (A. Friberg, personal communication 12 Dec. 2023), which may have reinforced the increase. It is common that both landowners and hunters have a positive view on fallow deer and that they value the hunting possibilities and the meat. Fallow deer often seem welcome when they arrive on new grounds (Carlström & Nyman 2005). This may be expressed as that few, if any, deer are harvested in the early years of a new establishment. When hunters do start to harvest a new establishment, they are generally protective of females and calves, and instead they primarily shoot males.

Something that might further benefit an increase of fallow deer numbers, is that hunters want to have a lot of fallow deer also because they can be hunted without any regulations as for

moose and red deer. That fallow deer harvest is not regulated seem to increase the popularity of the species among hunters, which paradoxically can result in an even larger population.

Carlström & Nyman (2005) states that the sex ratio is disastrous in many areas in Sweden with only one male of an age two years and older per 10 – 20 adult females. Trophy hunting in combination with an unwillingness to shoot females has created populations with a highly skewed sex ratio. After 1 October when hunting with dogs is allowed, it is also difficult to shoot females when the hunted deer move in dense and large groups, perhaps in high speed. Swedish hunters do not want to risk shooting a hind that has a calf, and in these shooting situations it is difficult to see if a particular hind has a calf. Easier then to shoot a male.

Males seem to have more protection on large estates with a planned and organized game management, but in many hunting units it is generally the males that are subject to harvest. The overharvest of males is further emphasized because the wider movement patterns by males compared to females, often including a seasonal migration between rutting areas and the areas where they spend the rest of the year (Davini et al. 2004, Borkowski & Pudelko 2007, Kjellander 2011). The hunting season before the rut in September has probably a large negative impact on male survival (Carlström & Nyman 2005). The problem with the overharvest of males and the counterproductive male hunting period in September, has been addressed several times over the years, but has nevertheless remained (A. Friberg personal communication 12 Dec. 2023, D. Jönsson personal communication 13 Dec. 2023, Jarnemo 2020).

Harvest data (Viltdata.se, The Swedish Association for Hunting and Wildlife Management) reveals that for hunting season 2021/2022 adult males constituted 24 % of the harvest, adult females 33 %, and calves 42 %. However, it is unlikely that the harvest of males reflects the actual adult male ratio in the population. The combination of that females are underrepresented and males overrepresented in harvest (Carlström & Nyman 2005) results in a high male ratio among the harvested deer not in accordance with the ratio in the population. Furthermore, it seems common that hunting units to a large extent shoot yearling males (A. Jarnemo personal observations, D. Jönsson personal communication 13 Dec. 2023), thus indicating that yearlings make up a large portion of the harvested males.

1.6.2.2 Increased damage of fallow deer and more protective shooting

The increase of fallow deer has been accompanied by an increase in damage and in applications for special permits for protective shooting of fallow deer to protect crops in several counties (Persson 2015, Jonsson 2019, Grahn 2021, Sjögren 2021, Åsenheim 2023). During 2014 – 2020 the damage (loss in harvest) by fallow deer on wheat, oat, rye, barley, and maize in Sweden increased from 9 500 to 28 500 tonnes (Jordbruksverket 2021).

Calves can be shot to protect crops during 1 July – 15 April without the need to apply for a permit at The County Administrative Board. It is also possible to apply for a permit to shoot adults to protect crops. However, in Södermanland the County Administrative Board found the that situation had become so serious that they decided to proclaim a general permit for protective shooting of fallow deer during 1 May 2022 – 31 August 2023. In August 2023 a new decision was taken to prolong the protective shooting with 2 000 deer during 1 September 2023 – 31 August 2025, and also allowing shooting during night-time.

In Västra Götaland the County Administrative Board came to the same conclusion as Södermanland, and decided on a general permit for protective shooting of 1 500 fallow deer during 16 October 2022 – 28 February 2025. The hunt is allowed also during night-time.

Östergötland followed Södermanland and Västra Götaland and proclaimed a general permit of protective shooting of totally 1 500 fallow deer during 16 November 2023 – 31 August 2025 in eight out of thirteen municipalities. Protective shooting being allowed during night using spotlight, night vision, and thermal imaging devices.

1.6.2.3 Voluntary fallow deer management units

One consequence of the increasing fallow deer numbers and the related increases of damage problems, is the establishment of voluntary management units. This has been done in Skåne, Södermanland, and in Östergötland. In Skåne the initiative was taken by landowners and hunters themselves, whereas in Södermanland and in Östergötland, the County Administrative Board, together with organizations representing landowners, farmers, and hunters, have been active. The management unit in Skåne was established in 2012, the units in Södermanland in 2016, and in Östergötland in spring 2023. Especially the units in Södermanland and Östergötland can be seen as a direct consequence of high population densities and severe damage.

The voluntary fallow deer management units are organised within the Moose management units. In 2019 18 out of 43 Moose units had active voluntary fallow deer management units (The County Administrative Board Södermanland 2019).

The main goals were to decrease damage by decreasing fallow deer density, but also to improve composition by creating a more even sex ratio, increase mean age among males and keeping a sustainable and goal-oriented annual harvest (A. Nilsson, personal communication 10 Dec. 2023). These are goals that seem central and general for voluntary fallow deer management units in the other counties as well. However, in Södermanland there were also management units with low fallow deer densities that wanted to increase density, and there was also a desire to increase the possibilities to harvest deer with large trophies by increasing the ratio of males at a peak age.

So far, the outcomes of the voluntary management units in Södermanland have been both negative and positive (Länsstyrelsen 2019, A. Nilsson personal communication 10 Dec. 2023). It has been difficult to decrease damage, and there is still severe local damage. It has proven difficult to improve sex and age structure. One probable cause is that there are hunting units within the area of the management units that do not participate and continues to shoot a lot of males. A related problem is that there are members in the management unit that are reluctant to report their harvest. The damage problem can be too dominating in discussions, leading to that other goals and aspects are pushed into the background. Furthermore, the general permit for protective shooting of fallow deer in Södermanland has created friction between members of the management units, aggravating cooperation (A. Nilsson personal communication 10 Dec. 2023).

On the positive side, the voluntary management units have resulted in a higher involvement in and interest for fallow deer and the management of the species. The awareness of problems and management has increased. Landowners and hunters now meet in a joint forum for dialogue and discussions. Members have acquired a greater knowledge of fallow deer, and

there is a willingness to learn more. The management unit is also a platform for spreading knowledge and information. The management units have taken the initiative to start systematic surveys of the fallow deer populations (spring counts, A. Nilsson personal communication 10 Dec. 2023), and the sharing of population data and harvest statistics, has given an improved knowledge of the local populations. The cooperation and that people get to know each other better have led to that hunting units now have started to hunt together.

A prerequisite for a chance of a successful outcome has probably been that the different landowner and hunter organizations, together with the County Administrative Board, have offered much help and support, and doing so without having a political agenda or by causing debates. Instead, they have encouraged their members to have a dialogue, to obtain knowledge, and to compromise in order to find a common direction for the work in the management unit (A. Nilsson, personal communication 10 Dec. 2023).

The voluntary management unit in Skåne started in 2012 with the aims to decrease damage by decreasing population density through an increased female harvest, and to increase the number of mature males. The purpose was also to increase knowledge about fallow deer management and to create a community across the borders of hunting units. The management unit includes 34 hunting units, totally encompassing 5 000 ha (T. Espgård personal communication 13 Dec. 2023, and P.-E. Jensen personal communication 14 Dec. 2023).

One of the most important positive effects of the joint management unit is an increased understanding and a respect for different interests and opinions among hunters, landowners, and farmers. There is an increased sense of community, and the meetings are socially enjoyable. One problem is when there is change of hunters in single hunting units. Either that the new hunters choose to not participate, or that they are willing to participate and then have to catch up with the others regarding management issues (T. Espgård personal communication 13 Dec. 2023). Another problem is the hunting units that do not want to be part of the management unit, either because the landowners are negative to the ungulate populations in the area, or that they disagree with members of the management unit (P.-E. Jensen, personal communication 14 Dec. 2023).

It has been very difficult to increase male ratio and especially the ratio of mature males with large trophies, but there is a difference in number of mature males compared to when the management unit was initiated in 2012. Males move over larger areas than females, and a significant number of males are probably shot in hunting units that do not participate in the joint management. It is important to put efforts in trying to get as many hunting units as possible to join the management unit (P.-E. Jensen, personal communication 14 Dec. 2023).

The landscape in the management unit is dominated by agricultural fields and the population is monitored yearly in spring through a count from car along routes. The counted number of deer does not indicate that the population has decreased since the start of the management unit, nor does the annual harvest (Kronoparkens Dovskötselområde 2023).

1.7 Conclusions

The general open hunting season on fallow deer in Sweden has resulted in a female biased population where few males reach peak age. The high female ratio has led to a high

population growth capacity and a strong increase in fallow deer numbers. The Swedish fallow deer population thus follows an often showed pattern for ungulates in unregulated harvest systems (Beddington 1974, Ginsberg & Milner-Gulland 1994, Langvatn & Loison 1999, Solberg et al. 2000, Festa-Bianchet 2003, Coltman et al. 2003, Garel et al. 2007, Sunde & Haugaard 2014, Torres-Porras et al. 2014).

Interestingly, fallow deer have shown a strong increase also within the area of the license management of red deer in Skåne. In the same area, and often in the same hunting units, where the red deer population is kept stable, and where hunters have learned to shoot females and sustain a balanced harvest, the fallow deer population increases, and hunters seem reluctant to shoot fallow deer females.

The large increase in fallow deer numbers has led to severe damage, mainly on crops. The number of permits for protective hunting has risen steeply in many counties in Sweden, and a general year-round protective shooting has been proclaimed in three counties. Pressure from landowner and farmer organizations has led to prolonged hunting seasons, to a free protective shooting of calves during 9.5 months of the year, and the possibility to execute protective shooting during night-time using spotlight, night vision, and thermal imaging devices.

What the increasing fallow deer populations have not led to, is a general insight that one important underlying cause of the fallow deer problems is the unregulated hunting, and that the solution lies in a planned, regulated management system with a balanced and expedient harvest, rather than in prolonged hunting seasons or vast protective night-time shootings. During the first year of the general protective shooting in Södermanland 49 % of the harvested fallow deer were males, 33 % calves, and only 18 % females (The County Administrative Board of Södermanland, data downloaded 14 Dec. 2023).

However, there are hunters, landowners, farmers, and wildlife administrators that realises that cooperation in management units offer a possible way to reverse the trend. The formation of voluntary fallow deer management units should therefore be seen as a reaction to the current problematic fallow deer situation in many counties in Sweden. The different voluntary management units have in common that their main goals are to decrease damage by lowering population density through an increased harvest of mainly females, and to increase male ratio and male average age. The general experience from the different management units, however, is that it is difficult to change age and sex ratio in the population, and that it takes time to improve the ratio mature males. The likely cause being that there are hunting units that do not participate in the management unit, and continue with a male-biased harvest.

A general conclusion from the voluntary management units is that they have resulted in a greater awareness and knowledge of management and in an increased understanding of problems, different interests and opinions of others. Neighbouring hunters and landowners have gotten to know each other and now meet in a joint forum for dialogue and discussions. The management unit gives a platform for problem solving, monitoring, statistics, and the spreading of knowledge and information. The support from the County Administrative Board, and from landowner and hunter organisations is emphasised as an important factor.

The voluntary management units seem to strongly rely on an active participation from landowners, farmers, and local hunters. One possible hindrance for a well-functioning voluntary management unit, might be if the hunters live elsewhere, and only visit the area during hunts, and perhaps then only during weekends. This could affect the possibilities to

arrange meetings, to conduct monitoring, to cooperate with neighbouring hunting units and with farmers, and to conduct measures to prevent damage.

One problem for the Red deer management units is that they do not have the corresponding support, the detailed instructions or the pressure to follow their plans, as the Moose management units have. The County Administrative Board has also less resources to devote to red deer management. Lack of support and detailed instructions, in combination with a generally low knowledge of red deer compared to of moose, are probably important explanations to why there are large variations in performance and efficiency among Red deer management units. However, the need for an increased knowledge about red deer ecology and management among hunters and landowners cannot be overstated. A better knowledge of the species, and how it should be hunted effectively, would be more expedient and justifiable measures for an efficient management, than would a prolonged hunting season or an abolishment of the regulated harvest system.

A common problem for Red deer management units seems to be to restrict male harvest. Management goals do not harmonize with planned and conducted harvest. Red deer management units are generally too small to manage a population of their own, especially regarding males. That the same individual males can be hunted in different hunting units at distances of up to 50 km due to their seasonal migrations, amplifies male overharvest. Management units would need to have a size of 50 000 – 100 000 ha, to encompass male migrations. An alternative is to coordinate male harvest between management units, similar to the coordination of Moose management units in Moose management areas.

This coordination is practised in the license management system in Skåne. The red deer population, the rutting areas, and the male winter-summer areas are well-known, wherefore license quotas and male harvest in rutting areas and in winter areas can be coordinated.

The license management system in Skåne has proven effective to obtain a more even sex ratio, to increase the ratio mature males, and to decrease local population densities when necessary. A thorough knowledge of the population through annual monitoring is one important pre-condition, the detailed license categories allowing the steering of the population in the desired direction another.

The approach of the red deer management in Skåne differs from the common approach of ungulate management in Sweden, i.e. that ungulate management is mainly a question about damage and hunting possibilities. Apart from considering damage and hunting possibilities, red deer management in Skåne has also a conservation approach, not only regarding a long-term viable population size, but also regarding age and sex ratios. When the management in Skåne aims for a high ratio of mature males, it is not for trophy reasons, but for that the mature males have an important role to play during the rut.

The conservation approach, where red deer ecology is central, has been paramount for the successful management of red deer in Skåne. To add a conservation approach in the management, regardless whether it concerns red deer, fallow deer, or moose, is probably something management in general would benefit from. When hunters and landowners understand why mature males are important in the ecology of red deer, it is easier to understand and accept why male harvest needs to be restricted.

A system of management units may be expedient, but it is a prerequisite that hunting units that do not participate have no, or at least very small opportunities to affect the population. It is also important that management units either are large enough, or coordinated in areas large enough, to encompass male movements. To divide hunting quotas into specific deer categories makes it easier to steer a population in the desired direction. It is beneficial to divide males into different categories in order to obtain a harvest in all age classes.

If the goal is to balance population density to an acceptable level with regard to damage and other interests, and if the goal is to reach and sustain an even sex ratio and a high average male age, a system where harvesting is unregulated cannot be recommended.

Regardless of harvesting system, support from authorities, landowner organisations and hunter organisations, is fundamental for a successful management, as is an increased knowledge of deer ecology and management.

2. Monitoring methods of red deer and fallow deer in Sweden

2.1 Monitoring of red deer in Sweden

2.1.1 Harvest statistics

Harvested red deer must be reported to the County Administrative Board within two weeks after the termination of the hunting season. This applies to Red deer management units as well as to un-registered calf units, and to calves that have been shot to protect crops and forest plantations. Harvest statistics for local, regional, and national levels can be retrieved at Viltdata (<https://rapport.viltdata.se/statistik/>), administered by The Swedish Hunters' Association.

2.1.2 Traffic collisions involving red deer

Traffic collisions with red deer must be reported immediately to the police by calling the emergency number 112. However, it is well-known that far from all wildlife-vehicle collisions are reported and therefore are lost in the statistics (Seiler & Jägerbrand 2016). So far, the statistics of traffic collisions with red deer has had a limited use in red deer management in Sweden. Red deer were involved in 453 traffic collisions in Sweden in 2022 (Nationella Viltolycksrådet, data downloaded 2023-12-08).

2.1.3 Methods for surveying red deer in Sweden

There are several various methods used in monitoring deer (Mayle et al. 1999). Morellet et al. (2011) found that at least 18 methods were used in Europe to census red deer, but did also conclude that there were large inconsistencies and a range of drawbacks that could be listed for most methods. Also in Sweden, several methods are used to census red deer, but to what extent different methods are used, or how reliable these methods are, have not been investigated. The Environmental Protection Agency has concluded that there is a need for reliable survey methods for red deer and for coordinated, generalized recommendations, data collections, and data storage (Naturvårdsverket 2015a,b). The following compilation is thus just a list of methods known to be used by Red deer management units, larger hunting estates, or in the red deer management in Skåne.

2.1.3.1 Pellet group count

Pellet group count is a reliable cost-effective method (Rönnegård et al. 2008, Hörnell-Willebrand & Pehrsson 2010, Månsson et al. 2011) that is recommended and widely used in Swedish moose management to get an index of population trends. Combined moose and red deer management units may therefore also include a simultaneous count of red deer pellet groups. However, pellet group count is probably a less reliable method for red deer than for moose. It is difficult to distinguish pellets from roe deer, red deer, and fallow deer, leading to a high risk of misidentification (Spitzer et al. 2019). Pellets from red deer also seem to decompose faster than moose pellets, leading to that pellet groups may have disappeared already before the count in spring (Jarnemo et al. 2010). Furthermore, decomposition rate can vary between different habitat types, as well as between different winters due to weather conditions (Harested & Bunnell 1987, Lehmkuhl et al. 1994, Skarin 2008).

2.1.3.2 Aerial censuses

Aerial censuses are generally used for moose in Sweden, and to a lesser extent for red deer. As for pellet group count, a simultaneous count of red deer can be included during aerial counts of moose (Svensk Naturförvaltning 2010). The general method for aerial censuses is probably with helicopter and using distance sampling methodology (Hörnell-Willebrand & Pehrsson 2010, Svensk Naturförvaltning 2010).

Aerial censuses primarily directed at red deer have been conducted a few times in Kolmården (Södermanland-Östergötland), Skåne, and Blekinge. The censuses were total counts using helicopter in February (post-harvest). Timing of census was chosen to give as ideal conditions as possible with fresh snow cover and a clear sky. The estates surveyed were systematically overflowed, covering the whole area. When observing tracks of red deer heading into dense forest stands (typically Norway spruce *Picea abies*), the helicopter was lowered to just above the tree tops, scaring the deer and making them leave the forest stand, whereby they could be counted.

2.1.3.3 Observations collected during hunting

Alongside pellet count and aerial census, observations collected by hunters' during hunting is one of the three most frequently used methods to monitor moose in Sweden (Hörnell-Willebrand & Pehrsson 2010). However, the method seems less reliable for red deer, possibly due to a more complex relationship between observations and harvesting effort/techniques than for moose (Mysterud et al. 2007). It may also be that the group-living red deer is more difficult to count and classify when passing the hunter in high speed and in large groups. Red deer can also refuse to leave the hunted forest stands and remain in these until dark (Jeppesen 1987, Sunde et al. 2009), which may add further complexity to the relationship between harvesting efforts and observations.

Since 2016 Swedish hunters are recommended to also collect observations of red deer (and preferably also, roe deer, fallow deer, and wild boar) during the hunting season. Observations can be reported online at Viltdata.se (Svenska Jägareförbundet 2016).

2.1.3.4 Roadside counts

Driving with car on a beforehand set route at dawn and/or at dusk and counting observed deer is probably one of the more common survey methods among larger estates and Red deer management units in Sweden, especially in landscapes where the deer are attracted to agricultural fields. The method can also be combined with spotlight or thermal imaging devices. The survey is often conducted in spring when the deer are especially prone to visit fields before green-up in the forest, but the survey can also be conducted during the rut. At present the use of roadside counts seem to increase among Swedish Red deer management units (Andersson 2020).

The data should, however, be treated with caution. There is a large risk of underestimating population size (Collier et al. 2007, Morellet et al. 2011), and the collected data may instead be of better use in creating an index of population trends between years. Spring counts may though be highly dependent on timing of spring, making replication difficult, and thus affecting the data collected (Mysterud et al. 2007).

2.1.3.5 Rut count Skåne

An annual count of red deer is conducted in the red deer management area in Skåne (Jarnemo et al. 2017). Red deer is counted during the rut (approximately 23 August – 5 October) in three core areas within the management area. The rut has the advantages that the deer expose themselves to a greater extent, and that males and females are not geographically segregated (Jarnemo 2008, 2011, Jarnemo et al. 2017).

Given the general behaviour of the red deer in Skåne to forage in agricultural fields during night-time and to seek cover in dense forest during the day (Allen et al. 2014), the counting is performed during evenings, nights and mornings. Observations are made from car and by foot, either from fixed points or by moving in the areas (driving car or stalking). During dark hours, a 2nd generation night-vision scope with 5.6x magnification is used. The night-vision enables that several rutting areas can be visited the same night and thereby increase the number of visits to each rutting area. Morning surveys start at 2.30-4.30 am and end at 8-10 am and evening surveys start at 5-6 pm and end at 9-12 pm. During one morning or evening shift, one to five rutting areas may be visited (Jarnemo et al. 2017).

Observed deer are categorised as calves, males, yearling males, sub-adult males estimated 2-5 year old, and mature males estimated 6 years and older. Yearling females are not separated from older females. The classification of yearling, sub-adult or adult males is based on body morphology and antler characteristics (Hetschold and Vorreyer 1968; Krebs 1969; Drechsler 1988; Jarnemo 2011). The highest numbers of females, calves, and yearling males obtained during any of the visits in each rutting area are the figures used for that rutting area, and these maximum numbers for all rutting areas are summarized as the total numbers of counted females, calves, and yearling males in the surveyed area. For males two years and older the total number in the surveyed area is based on the number of identified individuals during the whole rutting season. Individual stags are identified by antler shape (Clutton-Brock et al. 1982) and photo-documented or sketched and described in detail.

The data collected gives a number of counted deer and an age and sex ratio in the population. The number of counted deer is not used in management as an absolute measure of population size, but as an index of population trends.

2.1.3.6 Rut observations in Skåne

Since 2019 hunting units in the management area of the nominate subspecies in Skåne, have been asked to collect observations of red deer during the rut. The instruction is that during 1-5 occasions during the period 5-19 September (encompassing peak rut), place observers in observation points and simultaneously count red deer, and classify them as calves, hinds, yearling males, males 2-5 years old, males 6 years and older, and unknown deer. The design of the data collecting is the same as for the collection of moose and red deer observations during harvesting, with the difference that the rut observations are not collected during hunting. The idea is that data collection in situations when the deer are undisturbed and easier to count and classify, should result in more reliable data. The hope is that the collected data can be used as an index (no. observations/observer hours) of population trends, and give an estimate of age and sex ratios. However, of the circa 180 hunting units, only 9 % on average have performed a count during 2019-2023, wherefore the data has not been possible to use in the management so far.

2.1.3.7 Counting at supplemental feeding stations

Counting at supplemental feeding stations is a method that have been used at least at some larger estates in Sweden (Jarnemo 2014). The count is performed in late winter, i.e. post hunting season, and preferably during snow cover and temperatures below zero, which will make the deer more prone to visit feeding stations. Before the planned date of counting, the supplemental feeding is reduced during 1-2 weeks. The deer are only fed a small ration that is totally consumed each day, but the deer should still know that there is a continuous supply of feed every day. 1-2 days before the planned counting, feed is supplied in abundance. During the evening for the count, all feeding stations are manned with observers. By simultaneous counting, and also by trying to correct for animals that are believed to have moved between different feeding stations, a minimum number of deer in the area is obtained, as well as an age and sex ratio.

In the winter 2006, a count at supplemental feeding stations was compared with an aerial census at two 2 000 ha estates in Kolmården (approximately 100 km southwest of Stockholm). The aerial census was made as a total count with helicopter. Conditions were ideal with a fresh snow cover and good visibility. For both estates a higher number of deer was counted at the feeding stations compared to in the aerial census (350 vs. 294, and 144 vs. 132 respectively). For one estate, age and sex ratios were highly consistent between the two methods, and for the other estate relatively consistent. For both estates the number of unclassified deer was higher in the aerial census than in the count at feeding stations (Jarnemo 2014).

2.1.3.8 Photo-documentation of adult males

Adult red deer males can be identified by individual antler characteristics (Clutton-Brock et al. 1982, Pemberton & Petley 2000). In Skåne photo-documentation of males during the rut has been an important part of the annual monitoring since 1971 (Sinding-Larsen & Larsson 1979, Sinding-Larsen 1983). The antlers of photo-documented males are compared with the antlers of males harvested, found dead or being killed in traffic, but also with males photo-documented during summer and with cast antlers, thus enabling the mapping of migratory connections between rutting areas and the areas where the males spend the rest of the year (Jarnemo 2008, 2014). As individual males generally retain their antler characteristics from year to year, it is possible to follow individuals for several years (Sinding-Larsen & Larsson 1979, Clutton-Brock et al. 1982, Sinding-Larsen 1983).

Knowledge about male seasonal migration is important in order to coordinate male harvest between rutting areas and winter areas, and avoid an overharvest of males (Jarnemo 2008, Kropil et al. 2015, Meisingset et al. 2018, Jarnemo et al. 2023). The identification of males has also contributed with an increased understanding of male movements between different rutting grounds during single rutting seasons (Jarnemo 2011).

It has been suggested (Naturvårdsverket 2015b) that identified and documented males perhaps can be used as marked individuals in a capture-mark-recapture technique, or in this case observe-identify-resight technique, to estimate population size by Petersen estimate (Buckland et al. 2000). However, to use identified males as marked individuals is not unproblematic. The capture-mark-recapture technique relies on the assumption that marked (identified) individuals should be equally represented in the resighting sample as unmarked (unidentified) individuals. Females, calves, and yearling males are in general difficult, and in practical management probably impossible, to reliably identify, and for males 2 years and

older, there is an increasing chance for a reliable identification with increasing age and antler size, at least up to an age of 5-6 years. The mature males are thus more likely to get an identification, and because it is generally mature males that become harem holders during the rut, they might also be easier to observe. It is also a problem that it might be difficult in some situations to see whether it is an already known identified male or an unidentified male.

2.1.3.9 Camera traps

Camera trap technology to survey wildlife populations is widely used and has attracted a lot of research (Rovero et al. 2013, Trolliet et al. 2014, Palencia et al. 2021). The regulations concerning camera trap use in Sweden were eased in 2018, and it is common that hunters place camera traps on their hunting grounds, especially at supplemental feeding stations. These cameras are, however, seldom, if ever, used to estimate size or trends of game populations. Rather, hunters are interested in observing number of visits, and of what species, at the hunting ground or at the supplemental feeding stations.

There are ongoing projects that aim for a wider use of camera traps in Swedish wildlife management. Scandcam 2 is a joint Norwegian-Swedish research project that will develop a common system for using camera traps in wildlife monitoring. The Swedish Association for Hunting and Wildlife Management pursues a project that aims to develop a methodology where camera traps in reference areas will be used to monitor wildlife populations.

2.1.3.10 Drones

Unmanned aerial vehicles, or drones, perhaps combined with thermal infrared imaging, may offer new opportunities to monitor wildlife populations (Linchant et al. 2015, Witczuk et al. 2018). There are companies in Sweden offering the service of wildlife monitoring using drones, but so far it is not a method that is used in systematic monitoring of wildlife, even if some method development and field testing have been conducted (Eilert & Magnusson 2019, 2020).

2.2 Monitoring of fallow deer in Sweden

2.2.1 Harvest statistics

It is not mandatory to report fallow deer harvest to the authorities. The Swedish Association for Hunting and Wildlife Management is responsible for the administration of harvest statistics. Hunting units are asked to send in annual harvest reports to Viltdata.se. In combination with enquiries sent out, these data are used to calculate an estimated harvest on municipal, regional, and national level (Lindström et al. 2023, Thomas Ohlsson personal communication 8 Dec. 2023).

2.2.2 Traffic collisions involving fallow deer

Statistics of traffic collisions involving fallow deer are sometimes used as an index of population trends on a regional and national level. In 2022 fallow deer were involved in 5 617 collisions with vehicles in Sweden (Nationella Viltolycksrådet, data downloaded 2023-12-08).

2.2.3 Methods for surveying fallow deer in Sweden

2.2.3.1 Spring count

A recommended (Carlström & Nyman 2005, Varenius 2017), and perhaps the most common (Åström 2012, Varenius 2017, Lantbrukarnas Riksförbund 2023, A. Nilsson personal communication 10 Dec. 2023, T. Espgård personal communication 13 Dec. 2023) method to survey fallow deer in Sweden is a spring count in March – May. During this time of the year when spring green-up has started on the fields, but not in the forest, the deer are highly prone to graze on fields, especially on leys, autumn-sown crops, and semi-natural grasslands. The survey is conducted in the evening, preferably as a coordinated, simultaneous count that covers the hunting unit or management area (Carlström & Nyman 2005, Varenius 2017).

2.2.3.2 Roadside counts

Wildlife managers at large estates may conduct roadside counts, as described for red deer above. These counts are generally conducted in spring.

2.2.3.3 Observations collected during hunting

Since 2016 hunting units are asked to collect observations of fallow deer during hunting and report them to Viltdata.se (Svenska Jägareförbundet 2016). Large estates can keep a record of observed fallow deer during hunting as an index of population trends.

2.3 Conclusions monitoring

To be able to follow and foresee population trends, to estimate harvest quotas, and to investigate the impact of deer, an adaptive management requires reliable monitoring methods. There is a need for practical and cost-efficient monitoring methods, especially for red deer, but also for fallow deer.

Although several methods are used, in Sweden as well as in Europe, no method stands out from the crowd as the one to recommend. Spring count seems to be the established and general method to monitor fallow deer in Sweden, but the method remains to be thoroughly tested regarding reliability. Roadside counts (driving routes) in spring seem to be used by an increasing number of Red deer management units, especially in northern Sweden. However, the method is sensitive to the timing of spring, and it is questionable whether the obtained data is reliable. In the mixed forest-agricultural landscape, counting during the rut seems promising for red deer.

Rather than going for expensive and resource consuming absolute counts of population size or density, it is probably better to aim for reliable indices of population trends and changes of population composition.

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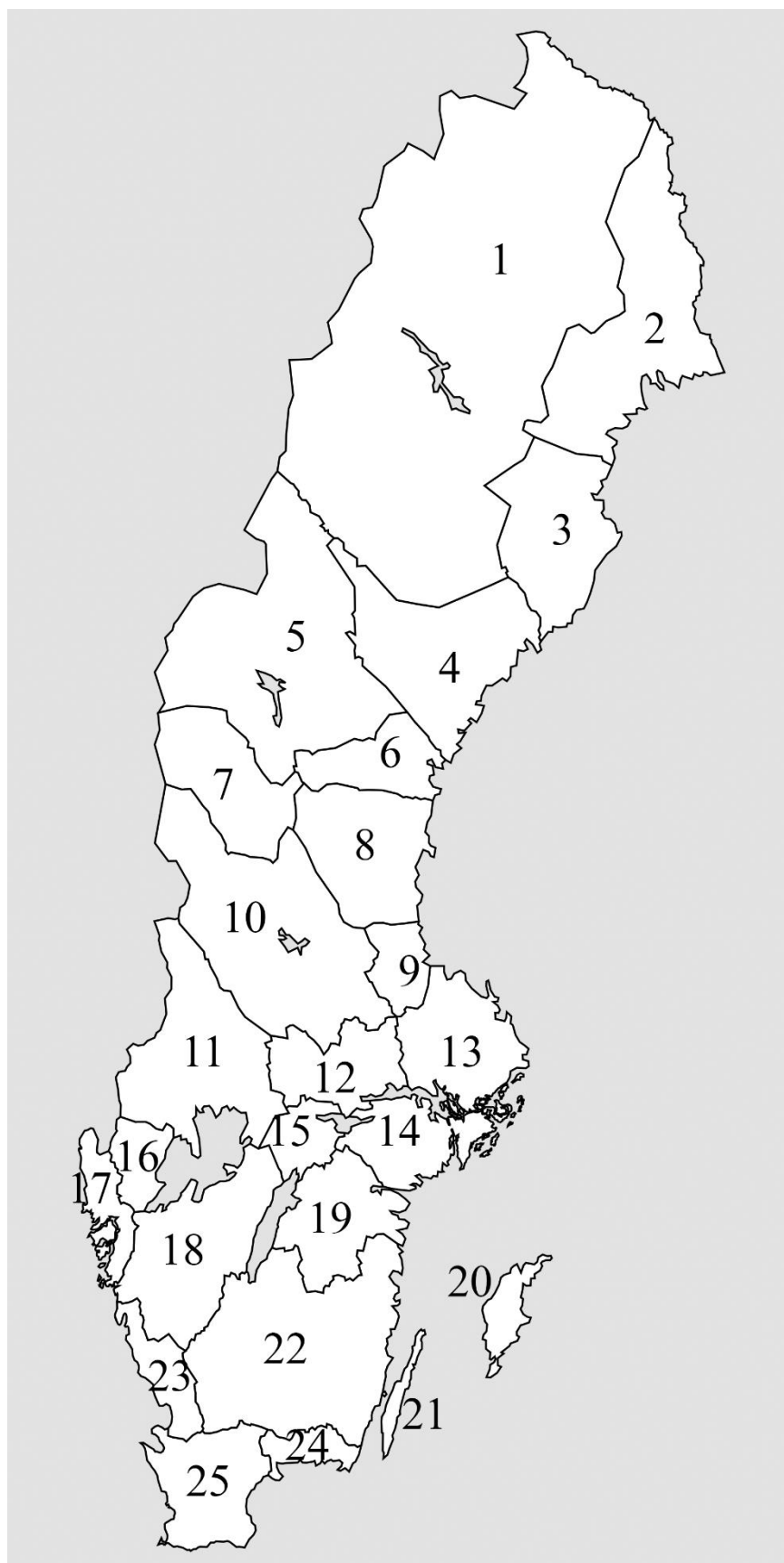
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Appendix 1. Provinces (“Landskap”) in Sweden



1	Lappland
2	Norrbottnen
3	Västerbottnen
4	Ångermanland
5	Jämtland
6	Medelpad
7	Härjedalen
8	Hälsningland
9	Gästrikland
10	Dalarna
11	Värmland
12	Västmanland
13	Uppland
14	Södermanland
15	Närke
16	Dalsland
17	Bohuslän
18	Västergötland
19	Östergötland
20	Gotland
21	Öland
22	Småland
23	Halland
24	Blekinge
25	Skåne

Appendix 2: The administrative counties (“Län”) in Sweden.



Map: Pegy22

Appendix 3: Hunting season for red deer in Sweden

Hunting season for red deer in Sweden apart from the county of Skåne.

- In Red deer management areas
 - 16 Aug. – 7 Oct.: Hinds and calves*
 - 8 Oct. – 31 Jan.: All animals
 - 1 – 28 (29) Feb.: Hinds and calves**
- Outside Red deer management areas (un-registered hunting units)
 - 16 Aug. – 31 Jan.: Calves*

* Only 'sit-and-wait' or stalking methods during 16 August – 30 September.

** Only 'sit-and-wait' or stalking methods.



Hunting season for red deer in the county of Skåne

- 8 Oct. – 31 Jan.: All animals.