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“Historical signs in the landscape”: Ecosystem services, motivation and challenges of pollarding in Western Norway

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Abstract Pollarding in agroforestry systems was traditionally an important practice for fodder acquisition in Western Norway, as well as in many other parts of the world. The practice has long been in decline, but to maintain cultural landscapes and biodiversity enhancement from pollarding, farmers now receive a public grant for each tree they pollard. In this interdisciplinary study we investigate which ecosystem services modern pollarding practices provide, under the influence of the current pollarding policy. We have performed both in-depth interviews and a quantitative survey targeting all pollarding farmers in the county of Vestland in Western Norway. We find that bioresources obtained from the branches from pollarding are to some extent still taken into use, mainly in the form of tree fodder for farm animals and firewood, but a lot of the branches remain unused. Biodiversity benefits are obtained from preserving old trees that often are located on agricultural land as solitary trees, as these trees provide important habitats, particularly for species growing on the bark, such as lichens and mosses, or within the decaying wood, such as, for example, fungi and insects. The modern practice of letting branches rot in the field provide habitats for insects and hence additional benefits to biodiversity. For the farmers, the main motivations to pollard are the cultural, aesthetic and historical values of pollarded trees. They see few disadvantages with pollarding, and most of them plan to continue in the future. The grant provides an incentive for pollarding, but our results indicate that the practice would continue without it, although less than now, especially with the establishment of new pollards.

Keywords Agroforestry · Cultural landscapes · Agricultural Policy · Livestock farming · Biodiversity · Traditional knowledge

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Introduction

Low-intensity farming systems such as agroforestry have been advocated as environmentally sustainable food systems that can contribute both to biodiversity enhancement and food security (Barthel et al. 2013). Previous studies have also established that agricultural landscapes containing trees have important cultural and aesthetic values (Rolo et al. 2021; van Zanten et al. 2013). One agricultural practice that

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has been used throughout history in many parts of the world, and in some places still today, is pollarding, a pruning system involving the removal of the upper branches of a tree, typically at a level where grazing animals cannot reach them, which stimulates secondary buds to grow as new branches over and over again (Turner et al. 2009). The potential economic, ecological and cultural benefits from agroforestry make it relevant to increase our knowledge about present-day management of agricultural systems including trees that are being pollarded, in this case in a region where pollarding traditionally was done mainly to provide fodder for livestock. This empirical study of Western Norway seeks to fill in these knowledge gaps using pollarding farmers in the region as informants.

Ever since the first people started keeping livestock in the Nordic countries more than 4000 years ago, it has been a challenge to provide them with enough fodder, and for thousands of years it was common to cut tree branches and feed animals with leaves and bark (Austad et al. 2003b). Traditionally, pollarded trees in Norway were situated in both forests, grazing land and hay meadows (Høeg 1974). Trees were pollarded in the late summer or early autumn and the foliage, which has high nutritional values and contains minerals beneficial to animal health (Smith et al. 2020), was dried and used as fodder during the winter months. Pollarded branches were gathered in bundles (called "kjerv") and dried in the outfields or inside outfield barns especially built for this purpose, where also hay was dried (Austad et al. 2003a). Branches and bark were used for agricultural tools and material for handcrafts (Hauge et al. 2014). It was a self-sustained, diversified agricultural system that provided resilience for instance in the event of failing grass harvests caused by climatic events such as droughts, frost or high precipitation (Visted and Stigum 1971). A recent study has found that when pollarding is done in an agroforestry system with hay meadows, where fodder harvesting is done both from the ground as grass and from the trees as foliage, it is possible to maintain the same level of fodder production as from an intensified production system reliant on industrial fertilisers (Rydgren et al. 2021). Furthermore, as the presence of trees in hay meadows increases carbon storage (Mosquera-Losada et al. 2018), such an agroforestry system can play an important role in climate change adaptation and mitigation (Rydgren et al. 2021).

Pollarded trees are examples of so-called culturally modified trees, which contribute to the formation of cultural landscapes where they manifest long-term management and land occupancy (Davidson-Hunt 2003; Turner et al. 2009). Being the result of human activities, pollarded trees can become incorporated into the culture and identity of the people who established and maintained them (Turner et al. 2009). Furthermore, particularly old pollards can acquire aesthetic values linked to personal sentiments and a "sense of place" (Blicharska and Mikusiński 2014; Garner 2004). As such, pollarded trees can produce cultural and social values that are important for the communities where they are located.

Pollarding reduces crown size, which prevents damages by wind and snow accumulation, and thereby uprooting and windbreak, increasing their chance to reach an old age. The size and age of these trees impacts their ability to host other species. Larger trees have more bark area available for epiphytic colonisation, and the longer the habitat has been available, the larger is the expected number of colonisations (Schei et al. 2013; Snäll et al. 2003). Furthermore, as trees age, the chemical and structural properties of their bark change (e.g. pH, crevice depth, thickness and roughness), increasing habitat heterogeneity and hence epiphytic species richness (Gustafsson and Eriksson 1995; Ranius et al. 2008). Old trees also tend to get hollowed, but in pollards this process happens at a younger tree age (Sebek et al. 2013). Hollow trees are key structural elements for a wide range of organisms including birds (Żmihorski et al. 2009), mammals (Ruczyński and Bogdanowicz 2008) and many saproxylic insects (Castro et al. 2013; Dubois et al. 2009; Sebek et al. 2013), and in Norway, as in the rest of Europe, the number of such trees is declining (Cálix et al. 2018). Many epiphytic and hollow specialists prefer open, sun exposed conditions, which mainly occur in managed woody pastures in the cultural landscape (e.g. Castro et al. 2013; Ranius 2002; Żmihorski et al. 2009).

More generally, scattered trees, as pollards in many cases are in the cultural landscape, provide a disproportionate number of ecosystem benefits given their size and the area they occupy. In addition to providing rare habitats, these benefits include increasing soil nutrients, structural complexity and habitat connectivity (Manning et al. 2006) as well as abundance and richness of arthropods and vertebrates (Prevedello et al. 2018) They may also facilitate ecosystem

services such as pollination, by providing nesting opportunities for cavity-nesting bees (Klein et al. 2006; Sydenham et al. 2016).

In Western Norway, pollarding was common until the beginning of the 20th century, when new methods for fodder harvesting were introduced. During the Second World War, pollarding was taken up again, but after that, the practice gradually went down (Hauge et al. 2014). This can be seen in relation to a general tendency in Europe, where cultural landscapes provided by for instance agroforestry are in decline due to the low economic returns of these low-intensity, diversified forms of agriculture (Barthel et al. 2013; Billen et al. 2021). These traditional farming systems are either replaced with more intense, monocultural forms of agriculture; or, in the case of more marginalised areas, cultural landscapes are either reforested or abandoned (Dittrich et al. 2017). Scattered trees on agricultural land are in particular decline because they take up space, reduce crop yield and make the use of machines more difficult (Blanco et al. 2019; Fleming et al. 2019).

Cultural landscapes are manmade and will disappear unless they are managed and maintained continuously (Schleyer and Plieninger 2011). Pollarded trees are particularly vulnerable to lack of maintenance, since this will cause the crown to become oversized compared to the tree's structure and root system, making it top heavy and more susceptible to uprooting (Read 2000).

Without some form of policy intervention there is a high risk of losing the ecological and social benefits from maintaining cultural landscapes (Simelton et al. 2021). On the other side, top-down policy encouraging specialized intensive farming, sustained yield forestry, and conservation efforts concentrated on the preservation of closed canopy forests compromise the future of traditional agro-silvo-pastoral systems (Bobiec et al. 2019).

To make agriculture more sustainable, policy makers must motivate farmers to apply more diverse land use practices which support biodiversity values, such as having solitary trees in agricultural landscapes (Sandberg and Jakobsson 2018). Previous studies find that although subsidies are important, there are also other factors which motivate farmers to maintain trees in cultural landscapes. These include aesthetic values (Fleming et al. 2019; Sandberg and Jakobsson 2018) sheltering functions for livestock (Blanco et al. 2019; Fleming et al. 2019; Sandberg and Jakobsson 2018), erosion control (Guimarães et al. 2023) and obtaining firewood from pruned or pollarded trees (Blanco et al. 2019). To our knowledge, no studies of farmers' motivation for maintaining trees in cultural landscapes have been carried out in Western Norway in the last decades.

In the county of Vestland in Norway, the county governor started a regional programme for subsidising pollarding in 2005.[1] Pollarding was seen as strategically important in the region because it was related to cultural landscapes, historical values and enhancement of biodiversity (County Governor Vestland 2019). When the pollarding grant programme started in 2005, farmers in the region Sogn og Fjordane could also receive grants for pollarding new trees, but as this resulted in large amounts of grant applications the policy was changed. It was decided that only already established pollarded trees were eligible for the grant, but if an old, pollarded tree died, it could be replaced with a new one belonging to the same group of trees. Another change in the programme was made in 2019: farmers could only apply for grant for the same tree every 5 years instead of every year, and they could only apply for 70 trees per year (before there was no limit to the number of trees). One of the reasons for this change was to make it easier for the County Governor to control if the trees had actually been pollarded (each year 5% of the pollarding farmers receive a control inspection). As a compensation to changes in the grant regime, the grant per tree was increased in 2019, it is now 500 NOK (43 Euro). A similar pollarding grant is also provided for farmers in four of the other fifteen regions in Norway (Rogaland, Viken, Vestfold og Telemark and Agder). In relation to the programme, farmers are informed about methods for pollarding via internet, including instructions that the branches and leaves should be cleared from the area to make it appear "neat and tidy".[2]

Using qualitative and quantitative methods to extract information from pollarding farmers in the Vestland county, the aim of this study is, firstly, to gain knowledge on modern pollarding, including on pollarding procedures and ecosystem services provided in terms of bioresources, social and cultural

[1] Before that, some of the municipalities had chosen to use grants earmarked for environmental purposes, for pollarding grants.

[2] County Governor of Norway https://www.statsforvalteren.no/vestland/landbruk-og-mat/skjult-side---landbruk/tilskot-til-skjotsel-av-styvingstre--styving-utfort-i-soknadsaret/

benefits and biodiversity conservation, as well as identifying the challenges connected with pollarding today. The second aim is to gain a better understanding of the role of agricultural policies in support for pollarding activities, and how it influences farmers' motivation for pollarding compared with other motivating factors. A deeper understanding of these aspects will better enable us to foresee the development of pollarding in Western Norway into the future and identify possibilities for obtaining more desirable outcomes, for instance with the help of policy measures such as grants.

Methods

The study site, Vestland county in Norway, is located within the area of the northern broadleaved deciduous woods in Europe, in a climatic transitional zone between the nemoral deciduous forests of southern Scandinavia and the widespread boreal coniferous forests to the north (Moen 1999). Broadleaved deciduous woodlands in this region have high species richness and several thermophilous species. In Vestland, 27% of the land is covered by forest, while 69% is open firm ground, bare rocks, inland waters, glaciers and bogs (Statistics Norway 2023b). The region is characterised by steep mountains and long fjords, and due to this topography, as well as soil and climatic conditions, only 3% of the land is used for agriculture, of which 98% is meadows (Statistics Norway 2023a). The total cultivated area went down by 5% between 2010 and 2020 (Knutsen et al. 2022), being mainly abandoned or afforested primarily with spruce (Cusens et al. 2024). The fjord areas of the region have an important and prosperous fruit production and are known for the beauty of the landscape which attracts tourists in the summer season.

The study was performed with qualitative (semi-structured interviews) and quantitative (survey) methods. Data collection and storage methods were compliant with ethical and legal privacy regulations as described by the Norwegian Agency for Shared Services in Education and Research (Sikt). To gain insight to the theme of the study, interviews were performed with a representative for the County Governor of Vestland, who is responsible for distributing the grant earmarked pollarding in the region, as well as a representative from the Norwegian Agricultural Agency working with grants related to agricultural landscapes. In addition, an interview was also conducted with a representative for the Farmer's Union in the region, who had special knowledge on pollarding. These three interviews were conducted in the period February to September 2022, and they were not recorded, but notes were taken. The questions were centred around the grant and the conditions for receiving it, as well as general information about pollarding in the region.

The information from these interviews, as well as information retrieved from literature, were used to create an interview guide. The interview guide consisted of questions related to how pollarding was done at the farm and the costs, benefits and motivation for pollarding.

Using the register for farmers who received grants for pollarding in the period 2019–2021, we selected 12 farmers for the in-depth interviews, with the aim to get a representative sample with respect to their number of pollarded trees, geographic location of farms, and age and gender of farmers. However, as farmers with more trees were more likely to say yes to the interview, more interviews were made with this category than with farmers with only a few pollarded trees. All the farmers were from the Vestland county, spread on the municipalities Voss, Kvam, Ulvik and Sogndal (Fig. 1).

We used semi-structured interview techniques, with the same interview guide for all interviews, but with follow-up questions. The interviews were conducted in the period December 2022-March 2023. All interviews were done during farm visits, which included a tour to see the pollarded trees. All farmer interviews were recorded and transcribed. The interviews were analysed with the computer software NVivo by two of the researchers who both coded all the interviews. Quotes from interviews are coded according to the four municipalities (A-D) and number of interviewees in each municipality.

The qualitative data were used to develop a questionnaire for an online survey. The survey contained questions that can be roughly divided into five groups: 1) descriptions of the pollarded trees, their location and what was done with the branches from the trees, 2) motivation for pollarding 3) challenges with pollarding, 4) knowledge acquisition and needs, 5) demographic information about respondents. The survey question categories and scales were selected according to the purpose of each question, using standard wording translated into Norwegian (Nynorsk).

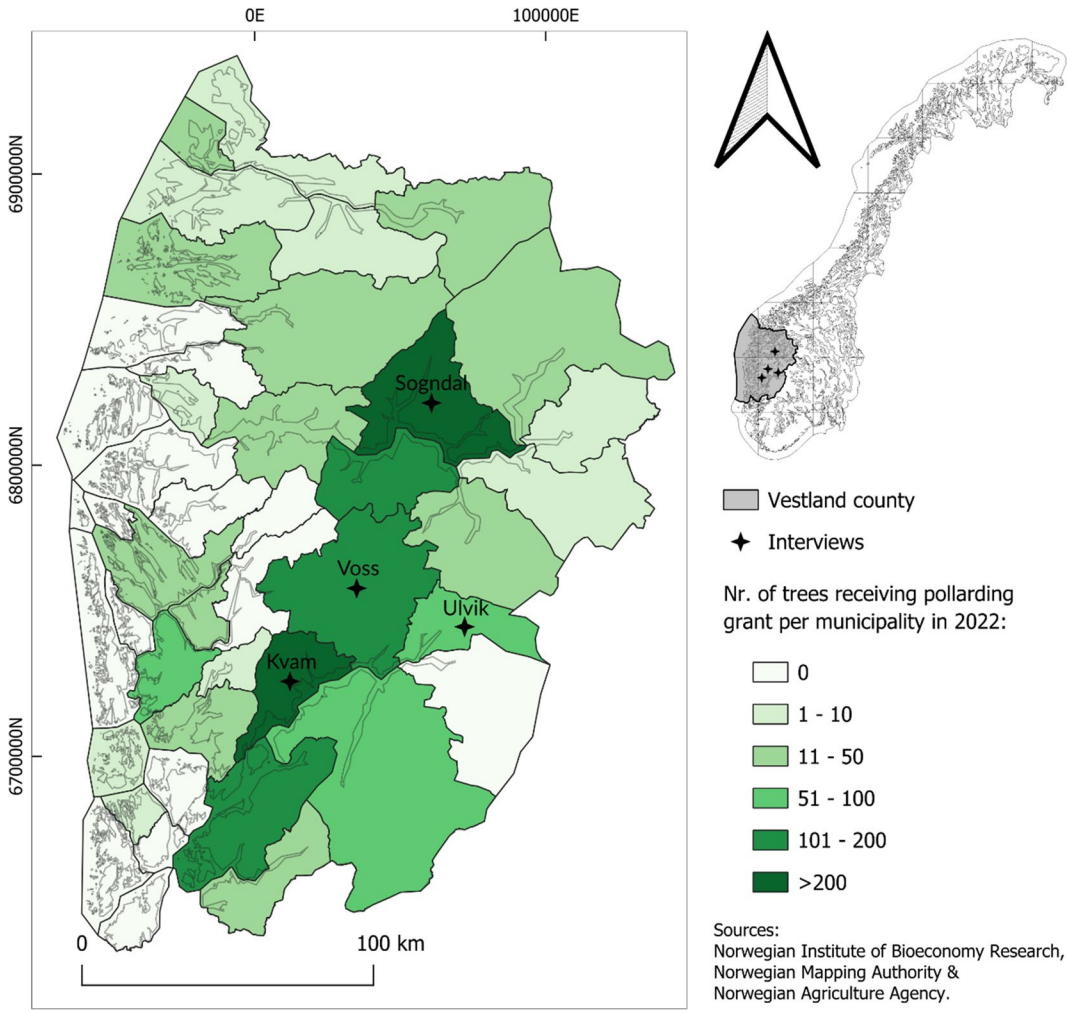

Fig. 1 Map of Vestland county, Norway. Shades of green show the number of trees that received pollarding grant per municipality in 2022. Municipalities where interviews took place are marked with ♦

The survey was sent out in October 2023 via email and phone message to all farmers who had received grants for pollarded trees in the Vestland county in the period 2019–2022. In the invitation to participate, the farmers were informed that four respondents would be randomly selected as the winner of a gift card from a national agricultural cooperative store.

The total number of pollarding grant receivers (2019–2022) was 367, but contact information was only available for 336 of these. Of these, we received complete answers from 137 and incomplete answers from 12 farmers. The response rate was thus 41% for the complete answers, plus 4% incomplete answers. Comparing the number of pollarded trees of those who answered the survey with those who did not, we find that those who answered on average applied for grants for 9 trees in 2022 (median 4), while those who did not answer applied for grants for 14 trees (median 6). Hence, unlike what one could expect, farmers with more pollarded trees were not more eager to answer the survey than those with less trees. This indicates that the respondents are not skewed towards farmers with a particular interest in pollarding.

The average age of the respondents was 53 years, and 70% had work outside the farm, which both is in line with the averages for farmers in Norway (Zahl-Thanem and Melås 2020). There were 12% women, which is slightly lower than for the total

Table 1 Location of pollarded trees in landscape

Location	Percentage
Infield pasture	80,4%
Border zone (near border to cultivated field, road, along river/lake etc.)	48,6%
Barnyard	39,9%
Hay meadow	31,2%
Rough grazing land	24,6%
In forest (for instance along footpath)	20,3%
Åkerholmar/field islands	5,1%
Other places	2,9%

Results

Pollarding procedures

Pollarded trees are located in several different types of landscapes (see Table 1), but the most common location is infield pasture, often in edge zones along fences, rivers, lake or fjord or on small infield islets/mounds that are unfit for harvesting and grazing (Fig. 2).

Among the survey respondents, 31% have pollards in hay meadows, and among these only 2 farmers did not harvest grass regularly (once or several times per year). Some pollards have probably been removed from hay meadows to allow efficient machine grass harvest, as this farmer explains:

> *"Everything (the pollards) is in the pasture, it would be impractical to have pollards in the*

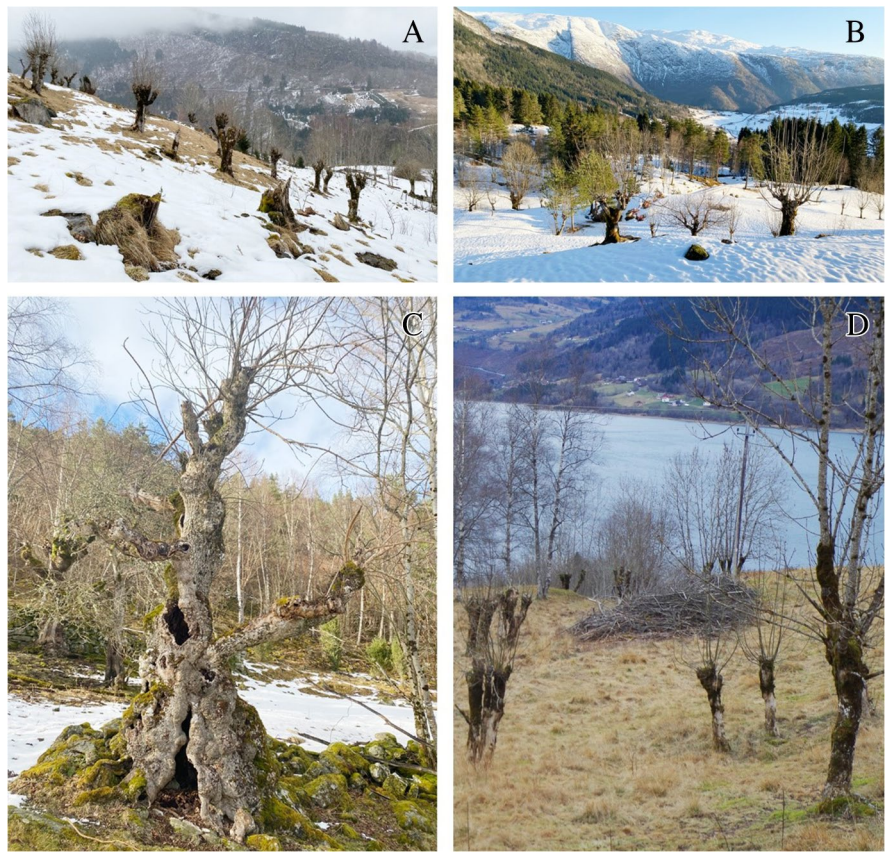

Fig. 2 Pollarded landscape in pasture in Grinde, Sogndal (**A**) and Ulvik (**B**). **C**) Old hollowed pollard. **D**) Pile of pollarded branches in pasture area, Voss

farmer population (16,4%) (Ibid). The average year for taking over the farm was 2001.

The data were collected using the online survey tool SurveyXact, figures were made in R (R Core Team 2023) using the tidyverse package (Wickham et al. 2019).

Table 2 Type of trees pollarded by farmers, with percentage of farmers having at least one of the species

Common name	Latin name	Percentage
Ash	*Fraxinus excelsior*	74,8%
Elm	*Ulmus glabra*	42,9%
Goat willow	*Salix caprea*	39,5%
Birch	*Betula pubescens* and *B. pendula*	31,3%
Rowan	*Sorbus aucuparia*	20,4%
Oak	*Quercus petraea* and *Q. robur*	*7,5%*
Hazel	*Corylus avellana*	4,8%
Lime	*Tilia cordata*	4,1%
Other		2,7%

hay meadows … My father removed some trees when he cultivated an area." A1

The most common type of pollarded tree is ash, which 75% of the respondents have. Elm, willow, birch and rowan are also quite common, while only a few farmers have oak, hazel and linden trees (Table 2).

One of the interviewed farmers explained that most of her newly established pollarded trees were birch, because she had animals grazing in the field where she wanted to establish them, and they would eat the ash trees, but leave the birch alone.

They [the sheep] are not fond of birch leaves, they have to be quite hungry to eat that. (Interviewee D1)

When interviewed farmers were asked about the ages of their trees it became clear that it was very difficult for them to tell, except for the ones that they themselves had established.

It's a guess. They are old at least, I'm sure about that. It wouldn't surprise me if they are a hundred years, maybe. (Interviewee B1)

During the farm visits the researchers observed that many of the pollards had been established in a period when pollarding was still a common practice for fodder acquisition and had reached a high age.

The survey results show that pollarding takes place in all seasons, but the most common is autumn (52%) and winter (42%). Only 16% of the farmers pollard in the spring and 26% in the summer. Traditional pollarding was done in the summer or early autumn when leaves are most nutritious. In the interviews some farmers explained that they pollarded in the autumn because the livestock were returning from summer pasture in the mountains and could eat the foliage from the branches as they were lying on the ground. Others explained that they pollarded in autumn because they were reminded by the deadline for applying for the grant on October 1st. Those who pollarded in winter said it was to protect the tree, and because it was easier to do it without the leaves when the branches were used as firewood.

Results from the survey show that 78% of the farmers do the pollarding themselves, and 18% share the work with someone else. Only 3% let someone else do the work. The qualitative interviews revealed that the most common tool for pollarding was chainsaw, and sometimes telescopic saw to reach higher. Most farmers explained that they also used a ladder when pollarding.

When asked in interviews how much time it takes to pollard, answers varied substantially, from 10 min to more than a day, depending on the size of the tree and its branches. There is a large difference between restoring an old tree that has not been pollarded for many years and establishing a new tree as a pollard. Of those who answered the survey, 65% had restored trees that had not been pollarded for more than 20 years,[3] and 64% had established new pollards.

There is a lot of variation in what farmers do with the branches after pollarding. The survey results show that a common practice was to let the branches rot in heaps in the field, and to use the largest branches as firewood (Fig. 3).

According to the survey results, 29% of the respondents sometimes make and dry bundles with pollarded branches (called "kjerv") to use as animal fodder, but only 7% always do it, and 41% never do it. However, it is quite common for farmers to let the pollarded branches lay on the ground and let livestock eat leaves and bark, which 19% answered that they always do. The 104 who answered that they use pollarded branches and foliage as fodder give them mainly to sheep (87%).

[3] The county Governor recommends to pollard at least every fifth or seventh year, depending on the type, age and growing conditions of the tree (https://www.statsforvalteren.no/vestland/landbruk-og-mat/skjult-side---landbruk/tilskot-til-skjotsel-av-styvingstre--styving-utfort-i-soknadsaret/).

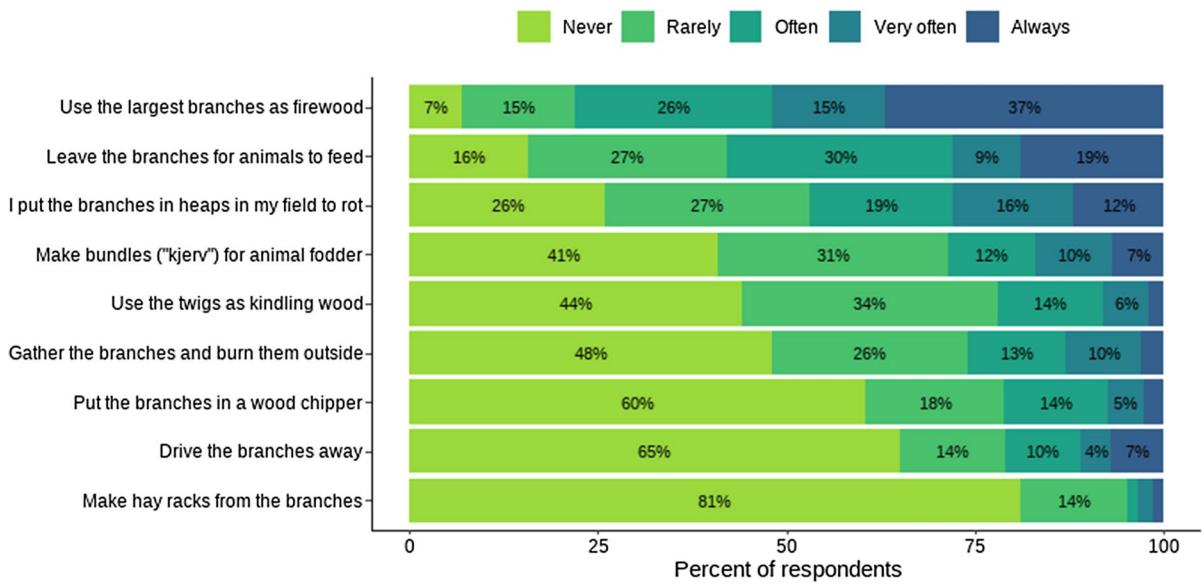

Fig. 3 Answer to question "What do you do with branches and leaves after pollarding?". Rounded percentages for each category are shown when the category reached at least 4%

Some also give them to goats (14%), cows (13%) or horses (10%).

Some of the farmers burn the branches, put them through a woodchipper, or drive them out of the area. Among those who sometimes use a woodchipper (57 of 147 respondents), the most common practice is to use it as bedding for farm animals in the barn (21 respondents) or to let it lay on the ground in the field (18 respondents), and there are also some (14 respondents) who compost it and use it as fertiliser. One of the interviewed farmers explained that before making the compost he would use the wood chips as bedding for the farm animals, and this had benefits both for the animals and for the composting process.

> *The wood chips heat up so it gets nice and warm for the sheep to lay on. And then you get some natural fertiliser mixed in, which is an advantage when you are going to compost it later. (Interviewee C1)*

This farmer said he had very good experience with using the compost as fertiliser in his hay meadows and for vegetable cultivation.

Motivation for pollarding

Survey answers on motivation for pollarding can be seen in Fig. 4, they are ordered according to average value given, from lowest to highest.

Cultural and aesthetic values of pollarding

The results of the survey show that "maintain the cultural landscape", "pollarded trees are nice to look at" and "history and tradition" are the most important motivations for farmers to pollard. This was also reflected in the qualitative interviews. The value of the pollarded trees was sometimes described as purely aesthetic, contributing to a landscape that is pleasant to look at, such as by this farmer:

> *It is perhaps first and foremost as a landscape element. I think they are incredibly beautiful, these trees. (Interviewee B2)*

In addition, as also the survey results show, for many of the interviewed farmers the history and tradition of pollarding seemed to motivate them to pollard:

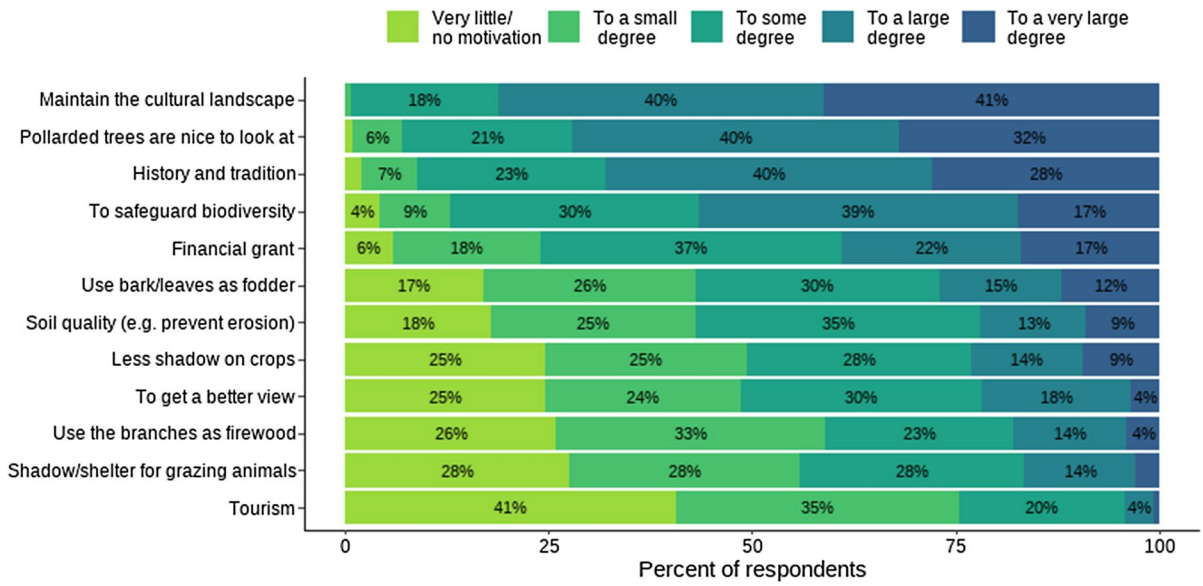

Fig. 4 Answer to the question "To what extent is the following a motivation for you to pollard?". Rounded percentages for each category are shown when the category reached at least 4%

It is to keep the tradition, and it's a nice way to show the history as well. That you see historical signs in the landscape. (Interviewee A1)

The aesthetic, cultural and historical values of pollarding were closely related and can be difficult to disentangle from one another:

Because nice pollarded trees are nice sculptures really, in the landscape, because they are telling a story. (Interviewee A2)

Most of the interviewed farmers talked about their own appreciation of the pollarded trees, but a couple also mentioned the pleasure that others take in looking at pollarded trees, such as this farmer:

Many people say it when they go hiking here, that they (the pollards) are nice to look at. (Interviewee C1)

The respondents to the survey answered that most of (58%) or some (38%) of their pollarded trees are visible for others along the main road, or near hiking trails. However, the survey also shows that tourism is not a major motivation for pollarding, which may reflect the fact that although many tourists come to the area, few farmers rely on tourism.

Biodiversity

In the survey, the majority (69%) answered that protecting biodiversity was a somewhat important or important motivation for pollarding, while for 17% it was very important.

Even though most of the interviewees acknowledged that pollarding probably has a positive effect on biodiversity, most did not mention it when asked with an open question about their motivation for pollarding. However, for some the effect on biodiversity was one of their most important motivations, such as these farmers:

It (pollarding) creates habitats and provides biodiversity. That is a minus with production and monoculture, so in that context pollarding is very important. (Interviewee B2)
So I think (…) it has a certain function for biodiversity (…) that's something that concerns me a lot (…) and I think I have read about some fungi and other things that are adapted to these trees. (Interviewee A1)

Those interviewees for which biodiversity was extra important, often showed a great interest in, and knowledge of biodiversity and how ecosystems function. One farmer described how his main motivation

for pollarding was his interest in biodiversity and to keep an open cultural landscape with a rich plant life:

> *If nobody was pollarding the vegetation would be different. You would have had more shade-tolerant plants, and less of the light demanding herbs growing on shallow soil. (Interviewee C1)*

The survey shows that 48% of the farmers gather the fallen branches and leave them to rot in piles in their farm area, instead of burning the piles. Many of the interviewees emphasised that this was, at least partly, in consideration of biodiversity:

> *We try to gather the branches and burn them, but often we put it in a pile and let it be. I'm thinking more and more that this is a better way, biologically. (Interviewee A1)*
> *Sometimes we have made piles and planned to burn them, but then spring comes, and they are full of life, so we can't burn them! As a result, we have piles of branches that are 20-30 years old. (Interviewee D1)*

One farmer had noticed that bumblebees often nest in his piles and was convinced that this had been a great advantage in a particularly cold spring when only bumblebees were active early enough to pollinate his plum trees. Since then, he decided to keep some of the willow that sprung up, as this is an especially important food resource for bumblebee queens early in the season.

Grants

The survey results show that the grant is an important motivation for pollarding, but it is ranked lower than both cultural and aesthetic values and biodiversity, and for 24% of the farmers it is not or to a very little degree a motivator (Fig. 4). During the qualitative interviews, none of the farmers said the grant was the most important motivating factor for pollarding, but several said they believed the other farmers in the area pollarded mainly because of the grant. One farmer told a story of his father who wanted to remove some pollarded trees, but when he told him about the grant, he was persuaded not to. One farmer said that he started pollarding because of the grant, but later came to appreciate the aesthetic values of the pollarded trees and this was now a more important motivation. Several farmers claimed that without the grant they would probably still pollard, but not to the same extent as today. For example, this farmer said:

> *Maybe if there was no grant you would have said: "Well, I'll do it next year", and then it wouldn't happen. (Interviewee D2)*

Likewise, one farmer said he would probably not have established new pollards without the grant. To the survey question if they had ever pollarded without receiving a grant, 82% answered "yes" while 10% were unsure.

During some of the interviews, it became clear that some farmers did not know how the grant system works, such as the size of the grant, the maximum number of pollarded trees they could get grants for, and that they could only get grants for trees already pollarded. Few had very clear opinions about whether they thought the grant was high enough or should be higher, but there were some who expressed that the hourly payment for the work was low, while others thought it was quite good.

> *It's an ok fee for the trees, but at the same time if you look at all of it, that you clear around and maintain the cultural landscape, it should be this much to stimulate it. Because the equipment costs a bit too, actually. (Interviewee D3)*
> *No, I can't remember what it was, 500 per tree? (…) It's probably ok. I don't have a strong opinion about it, really. (Interviewee D2)*

When asked in the survey if they were content with the grant, 62% answered yes, 18% said no and 20% were unsure. Of the 25 who said no, 16 farmers were discontented with the grant sum, 14 with how often you could apply for the grant, and 12 were discontented with the fact that you could only get a grant for a new tree if it replaced an old one.

Some of the interviewed farmers explained that the grant was important not because of the money they received to their bank accounts, but because it made it easier to make pollarding a routine:

> *I guess I would have done it to a certain degree, but now it's more on the schedule, as a routine because you must fulfil what you have applied for. So, it becomes a reminder, and you are trumped to do it. But I guess I would have pollarded anyway, but it would have been more occasional and sporadic. (Interviewee C1)*

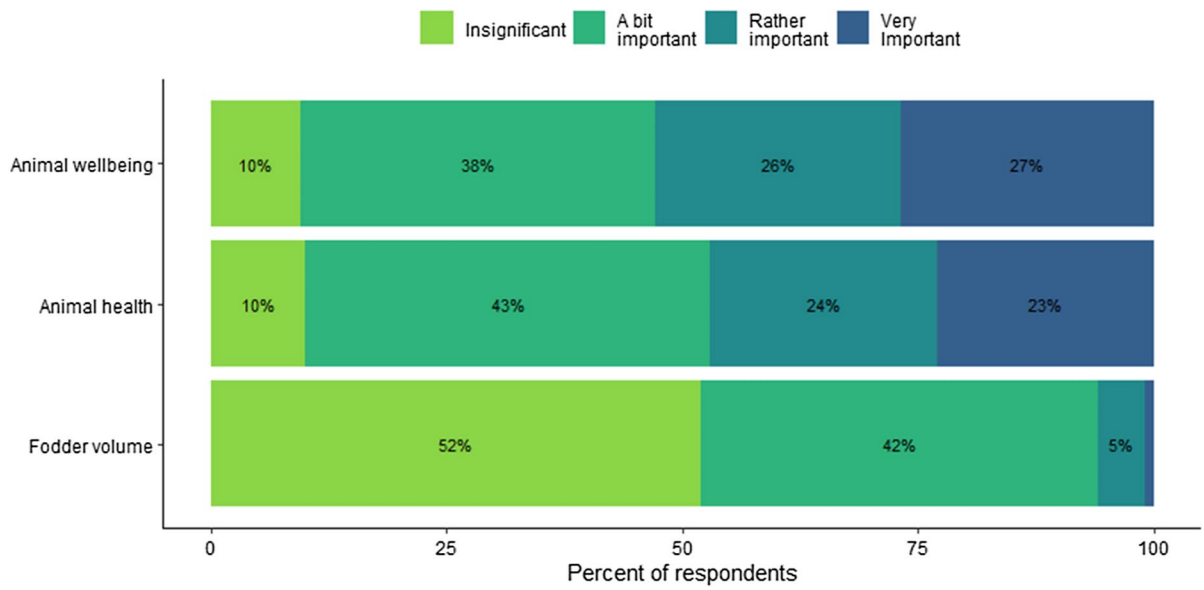

Fig. 5 Answer to the question "What is the significance of the fodder resources you obtain from pollarding?". The question was given to the 104 farmers who answered that they had given pollarded branches to livestock (N = 104). Rounded percentages for each category are shown when the category reached at least 4%

Fodder

As previously described, very few farmers used the pollarded branches as animal fodder in the traditional way (bundled as "kjerv"). However, during interviews it became clear that many of the farmers were aware that leaves contain minerals that are important for animal health, and especially useful for feeding sick animals which lose their appetite (for hay):

> *I have had animals that have been ill and not wanting to eat, but if you have leafage, they will eat it. It's very strange. So, I think it's very good to have some now with the lambing. Because there are always some getting a bit ill and then it's amazing…it's like there is something special about leafage. I only have ash leafage, so I have no experience with anything else. I know my father said ash leafage was considered medicine. D2*

Some of the interviewed farmers believed foliage could replace feed concentrate if harvested in sufficient amounts. Many also remarked that the animals were very keen on eating the foliage from the pollarded branches, and that they would gather around the tree, eating as the branches fell down.

> *It's very strange, in the autumn, when I come with the saw and start sawing the tree, then before the first branch has fallen the sheep are there. So that's a bit fun. (Interviewee A2)*

The survey results show that using pollarded trees as fodder is mainly seen as important because the animals like it and it benefits animal health, and for only 6 farmers it is rather or very important as a contribution to fodder (Fig. 5).

In interviews, several farmers talked about how pollarding was done historically, and some of the older informants could remember from their childhood when pollarding was important for fodder acquisition. One farmer explained:

> *Traditionally pollarding was very important here on this farm. Because it's on the sunny side and the soil is rather shallow, so often it would happen that the grass would disappear. Then we had to resort to pollarding, because there the harvest would remain high. (Interviewee C1)*

However, all the interviewed farmers considered it far too much work to pollard and make "kjerv" in sufficient amounts for it to contribute significantly to fodder volume.

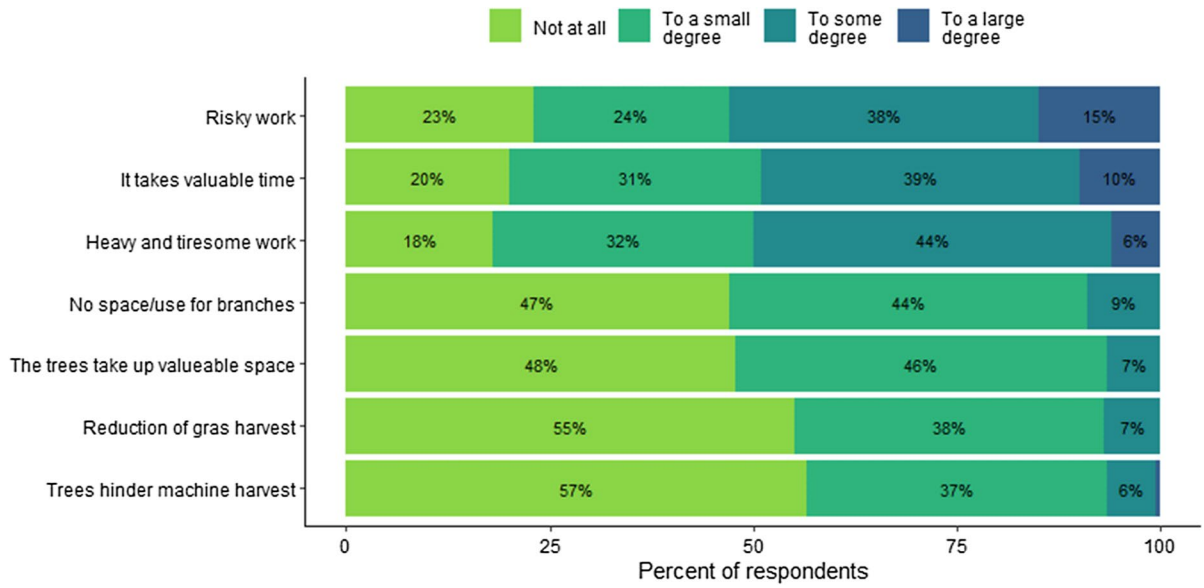

Fig. 6 Answer to the question "To what degree would you say that the following are disadvantages of pollarding?". Rounded percentages for each category are shown when the category reached at least 4%

I have maybe tried it once for fun, but not more. It is too much work and takes too much time. (Interviewee C2)

Other motivations for pollarding

During interviews, farmers mentioned different practical benefits of having solitary, pollarded trees in their fields. These potential benefits were added to the questionnaire (see Fig. 4). Among these benefits, having trees with roots binding the soil and hindering erosion was the most important. Some also pollard because if not there would be too much shadow in the field, which would reduce grass growth, while others do it because they want a better view. Pollarding to get firewood was less important, which is interesting because most of the farmers do it, at least sometimes (Fig. 3). The reason could be, as several farmers explained, that if they need firewood, it is much easier to cut down entire trees, which farmers usually have plenty of in these areas.

Challenges with pollarding

As previously described, pollarding trees can be time consuming and hard work. It is also not without risk, especially when branches are long and thick and there is a danger of losing control because they may crack unexpectedly, especially ash trees. Most of the farmers mentioned the hazards related to pollarding, but only one of the interviewed farmers told us about an accident when he was injured; he was severely hit by a branch when pollarding with a telescope saw without wearing a helmet.

When asked in the survey about disadvantages of pollarding, hazardous work was the most important, followed by that it takes valuable time, and that the work is hard and tiresome (Fig. 6). But there are more respondents who feel that these factors are not disadvantages, compared to those who think they are to a large degree. Very few are concerned with the disadvantages of trees or branches taking up valuable space, or reduction of grass production.

Pollarding can also be a challenge for the trees. In the survey, 10% answer "yes" and 24% "possibly" to the question if they have lost trees because they did not survive the pollarding (Fig. 7). Many had also lost trees because of tree diseases or insect attacks, which can be linked to the ash dieback disease spreading in the area in this time period (Timmermann et al. 2017). Of those farmers who had lost trees to diseases or insect attacks, 67% answered that it was ash, while 16% had lost elm trees, 12% had lost birch and 10%

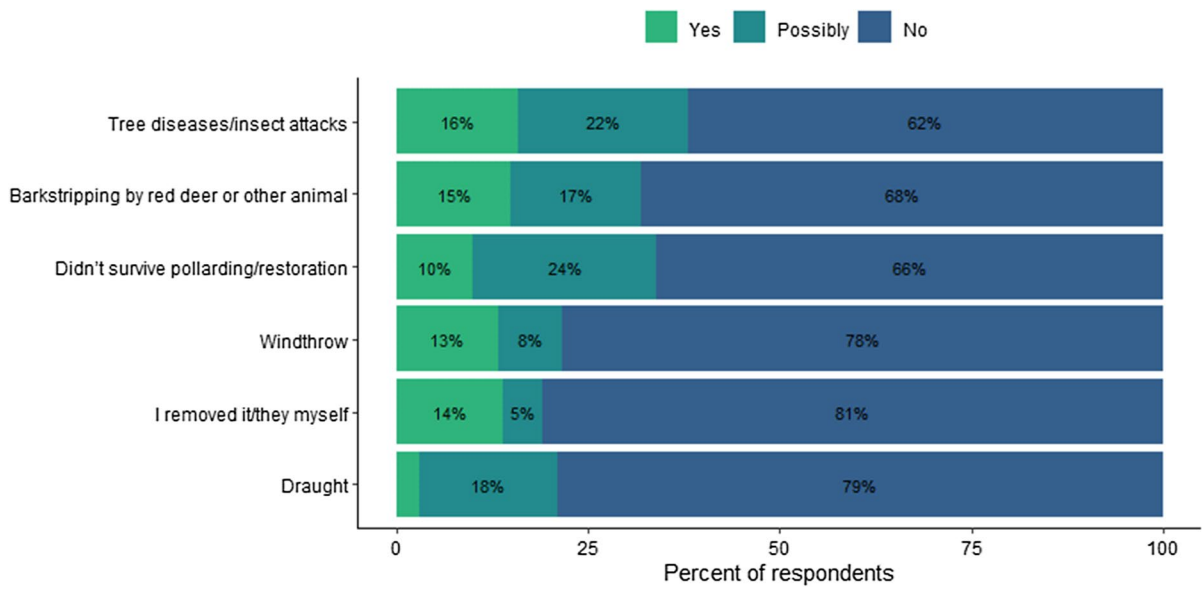

Fig. 7 Answer to the question "Did any of your pollards die from any of the following reasons?". Rounded percentages for each category are shown when the category reached at least 4%

Table 3 Answer to the question «How did you get knowledge about pollarding/restoring pollards?

	Percent
Learned it from those who ran the farm earlier (for instance parents or grandparents)	62%
I am mainly self-taught (have learned from trial and error)	32%
Read about the procedures in leaflet or on internet (for instance the county governor's pages on maintenance of pollards)	30%
Learned it from other relatives, neighbours or acquaintances	12%
Went to a course/talked with an expert	11%
Other	4%

willow. In the interviews, the ash dieback disease was a concern for many of the farmers, some of whom had a large number of ash trees that they pollarded. Other dangers for the trees are barkstripping by deer or windthrow. Some had also possibly lost pollarded trees because of drought. The high degree of uncertainty in the answers indicate that it is not always easy for the farmers to know what caused the death of their pollard. This is as expected, since the death can be caused by a combination of factors, including the pollarding itself.

We asked those who had removed pollards the reason why, and three farmers answered that the trees were blocking machine harvesting, while seven were going to use the area for something else.

To avoid trees from dying because of pollarding, knowledge is important. In both the interviews and survey, questions were asked about knowledge acquisition. The survey results show that most of the respondents had learned it from the previous farm owners, for instance parents or grandparents, hence a direct knowledge transfer taking place on the farm. Some also claimed that they were self-taught through trial and error, and almost the same amount had learned it from written information or on the internet (Table 3).

When asked if they needed more information about pollarding, 44% answered "No", while 51% answered "yes, some need" while only 6% answered "yes, a great need".

When asked how likely it is that they will continue with pollarding the next 10 years, 91% answer that it is likely or very likely, the rest believing it to be very unlikely (3,6%) or somewhat unlikely (6%).

Discussion

Trees have for thousands of years provided important ecosystem services to humans, one of these is fodder for livestock. In western Norway, pollarding trees was an agricultural practice of vital importance, but today the economic returns of fodder provision from pollarding are too low to be worthwhile for farmers (Austad et al. 2003a). To prevent the abandonment of the pollarding practice, public authorities provide grants to farmers for each tree they pollard (maximum 70 trees per year).

For the farmers participating in our qualitative interviews and survey, the bioresources obtained from pollarding have lost most of its previous significance. Some farmers still use the foliage as fodder, but more for the sake of animal welfare and health benefits than as a contribution to fodder volumes. Many farmers use the larger branches from pollarded trees as firewood, and a very small number make wood chips that are used as bedding for farm animals and sometimes composted and used as fertiliser. But most of the branches and twigs remain unused and are dispersed in heaps that are burnt or left decaying in the field.

Some farmers are motivated to pollard because of the erosion control and sheltering functions it provides to animals, but for most of the farmers in our study, the ecosystem services obtained from pollarding are first and foremost related to cultural and aesthetic values, which is in line with studies of agroforestry in other parts of the world (Burel and Baudry 1995; Fleming et al. 2019). In interviews, the farmers describe how they appreciate a landscape with pollarded trees because of the cultural heritage it represents. The practice of and knowledge about pollarding has been transmitted through generations up until the present, and the pollards are thus examples of culturally modified trees that offer opportunities to reconnect with the past, a phenomenon also found in many other parts of the world (Blicharska and Mikusiński 2014). Most of the farmers have pollarded trees that are visible to others from roads or hiking trails, and some of those interviewed mention that they know their pollards are appreciated by others. Still, more research on this topic is required to gain knowledge on to what extent the general population recognise pollarded trees, know about the historical context they were created in and appreciate their aesthetic and cultural values the way the farmers do.

The results of this study show that pollarded trees in Western Norway are mainly situated on farmed land, which means they grow as solitary trees in the landscape, which have large benefits to biodiversity, especially relative to their modest spatial occupancy and relatively low biomass of each tree (Manning et al. 2006; Prevedello et al. 2018). Because the interviewed farmers had little knowledge about the ages of their trees, we did not ask questions about this in the survey. But observations of old pollards made during farm visits, and the fact that 64% of the respondents had restored trees that had not been pollarded for more than 20 years, indicate that there are many old, pollarded trees in the region, which are important habitats for different species, also because they are more likely to be hollow (Sebek et al. 2013).

Newly established pollarded trees may not immediately provide the same biodiversity benefits as their older counterparts, due to factors such as size, age and habitat qualities. However, when these pollards are consistently maintained over time, they have the potential to surpass unmanaged trees in age, ultimately becoming vital contributors to future biodiversity. This is especially important as the most common pollarded tree species (ash and elm) are key stone species of Norwegian temperate deciduous woodlands, which constitute just over 1% of the total forest cover, but are among the most species rich forests in Norway, hosting ~ 30% of the forest-associated red-listed species (Henriksen and Hilmo 2015).

It should be noted that, although pollarding can contribute to an enhancement of biodiversity, our results also show that if not done correctly pollarding can also damage or even kill old trees: 34% of the respondents had or had maybe lost trees due to pollarding. Especially when restoring old pollards, or if the trees are already in peril due to barkstripping by deer or tree diseases, they need to be managed with care. The noteworthy mortality observed in pollarded ash trees is consistent with the larger pattern of ash dieback within the study region (Timmermann et al. 2023). Despite the recent introduction of the disease to this area, initially observed in 2011, its impact has been profound. By 2022, an alarming 52% of the ash

trees had died, with an additional 15% were experiencing severe damage or in the process of dying, while 20% where still healthy (Timmermann et al. 2023). Bengtsson et al. (2021) found that time since pollarding influenced the mortality of ash trees, and therefore recommend to only pollard ash trees that are in a regular cutting cycle and do not show any symptoms of ash dieback. Provision of information to the pollarding farmers is therefore highly important.

Our study shows that many farmers let the branches or twigs from the pollarded trees decay in heaps outside in the field, which increases the structural complexity of the landscape and provides nesting opportunities for animals (e.g. Brin et al. 2011). It is interesting to note that farmers are doing this against the advice of the county governor providing the pollarding grant, who wants the pollarded area to be "neat and tidy". This shows that in the formation of the pollarding policy the aims of achieving both ecological and the aesthetic values are balanced against each other, something which is typical in the management of cultural landscapes (Tyrväinen et al. 2003). In this case the aesthetic values of a tidy area get priority over biodiversity, but our study shows that the policy aims are not necessarily reached, as farmers do not always follow recommendations.

In line with studies by Sandberg and Jakobsson (2018) and Blanco et al. (2019) our results show that for the farmers, aesthetic and cultural values of pollarded trees are more important than their effect on biodiversity. However, some farmers seem to have a strong interest in and knowledge about biodiversity and how pollarding may affect it. The grant does not appear to be the most important motivator for pollarding, aligning with previous research on farmer motivation for participation in agri-environmental schemes (Blanco et al. 2019; Brown et al. 2021; Gatto et al. 2019). However, although the money itself may not be the main motivator, for some farmers the grant application deadline seems to work as a reminder to get the pollarding done.

A reason why the grant money itself does not seem to be very important, could be that livestock farmers in Norway already receive substantial amounts of subsidies (around 75% of sheep farmers' income are from subsidies (Gaasland 2020), and the pollarding grant is small in comparison. In Norway there is strong public support for agricultural subsidies to ensure agricultural employment opportunities in rural and marginalised areas (Mittenzwei et al. 2016; Vik 2020). A major part of the subsidies to livestock farmers are given per animal, which means it does not necessarily imply maintenance of cultural landscapes. Subsidies linked to production can reinforce a productivist, conventional agricultural regime, reliant on imported feed and high consumption of meat, with corresponding negative impacts on biodiversity, greenhouse gas emissions and public health (Loeng and Korsnes 2023). Subsidies earmarked for pollarding do not have such consequences. However, previous studies have found that many farmers prefer to get their income from their food production activities rather than receiving subsidies for landscape maintenance (Brown et al. 2021; Kvakkestad et al. 2015). Contrary to these previous results, our study shows that pollarding is perceived as meaningful work in several ways. Furthermore, unlike previous studies (Rivest et al. 2013), we find that very few farmers are concerned about the negative impact of pollarded trees on farm production.

Rydgren et al. (2021) found that wooded hay meadows with pollarded trees can function as a sustainable, biodiversity enhancing agricultural system that does not compromise food production. Our study shows that, although the bioresources provided by pollarding are to some extent taken into use by the farmers, it is not economically profitable to use the foliage as fodder due to the high work load it requires. Hence, for this to again become a common practice there is need for stronger stimulation, most efficiently in the form of grants earmarked for this purpose. Such a policy would be in line with Sandberg and Jakobsson (2018), who argues that for agricultural policy to instigate sustainability, there is need for a shift away from a strong production-oriented farming into more diverse land use practices to support biodiversity.

Continuing to give grants to activities such as pollarding is recommended because it is a way to support sustainable, traditional farming practices and preservation of cultural landscapes. Potentially, pollarding can provide a more sustainable source of fodder than imported feed and contribute to increased self-sufficiency and food security without compromising biodiversity (e.g. Barthel et al. 2013). With climate change and the prospects of more insecure access to food and feed (Gomez-Zavaglia et al. 2020), there will be an increased need for more sustainable, resilient agricultural systems, such as those provided by pollarding trees in hay meadows (Rydgren et al. 2021). It is therefore of interest that the tradition is kept alive.

Conclusion

Pollarding in western Norway was traditionally practised mainly for fodder acquisition. Our study shows that today, although few pollarding farmers consider it to give an important contribution to their fodder volume, many still give the foliage to livestock for animal welfare and health reasons. Farmers also appreciate other ecosystem services from having pollarded trees on their hay meadows or pastures, primarily the aesthetic values which also reconnect them with traditions of the past, in addition to more practical benefits such as sheltering and erosion control. For some farmers, biodiversity is also an important motivation to pollard. For policy implications, our results indicate that sharing information about the cultural heritage of pollarding and the benefits it may have on biodiversity, to farmers as well as to the general public, can be an important part of a strategy to uphold pollarding. Furthermore, it seems likely that without the economic incentives from the public grant, pollarding would to some extent continue, but it would be done more sporadically, and with less establishment of new pollarded trees, which is important for the long-term sustainability of this system. Upholding pollarding in this region therefore seem to require the continuation of a grant scheme. To provide additional benefits to biodiversity, it could also be considered to revise the advice against piling branches in heaps instead of burning.

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Author contributions A.B.M and F.H.S conceived the study. A.B.M., J.J. and S.K. developed interview guides and questionnaires and collected data. A.B.M. and J.J. analysed data and prepared tables and figures. A.B.M wrote the main text in collaboration mainly with J.J. and F.H.S. All authors contributed to literature review and discussion.

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Declarations

Competing interests The authors declare no competing interests.

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