

Effectiveness of a novel stainless-steel tree guard to reduce tree felling by Eurasian beavers (*Castor fiber*)

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Abstract

Rodent (*Rodentia*) diversity is essential to sustaining healthy ecosystems, but their tree damage causes substantial economic loss. Despite this, empirical testing of tree protection methods across rodent species remains limited. We investigated the effectiveness of a novel stainless-steel mesh in reducing tree felling by Eurasian beavers (*Castor fiber*), who can fell large quantities of woody material rapidly. We tested mesh effectiveness on apple trees (*Malus domestica*) and aspen branches (*Populus tremula*) in two rivers in southeastern Norway. We planted 19 pairs of apple trees and 18 pairs of aspen branches; within each pair, one stem was guarded and one was left unguarded. Camera traps monitored tree felling events and recorded behavioural responses by beavers and other animals. Tree guards significantly reduced felling of aspen branches when compared with unguarded counterparts. Conversely, guards installed on young apple trees, due to the presence of a low canopy restricting the height of the tree guard, facilitated beaver access to the lower branches and stem. Installation height was therefore an important predictor of guard mesh success. However, the presence of the guard still delayed time until felling of apple trees. Beavers often attempted gnawing when first encountering the tree guards. If they could not reach the canopy above, they rarely felled the tree. When correctly installed with adherence to proper installation protocol, stainless-steel guard meshes provide an effective solution for land managers seeking to protect trees of both economic and conservation importance.

Introduction

Browsing and felling by rodents (*Rodentia spp.*) is frequently reported as a common cause of tree damage in grassland, wooded and riparian zones, especially in forest plantations and orchards, where sapling damage can lead to substantial economic loss (Huitu et al. 2009; Suchomel et al. 2019). High rodent diversity is valuable to healthy ecosystem function by enriching food source availability, nutrient cycles and seed dispersal (Glaudas et al. 2008, Lessa et al. 2019, Sirotnak and Huntly 2000). Sapling stems often have a high sugar concentration, more easily consumable material and are generally situated at a lower, more advantageous height. These traits increase the caloric risk-reward pay-off for rodent foragers by providing the right balance of high-energy food with a low handling time (Wang and Yang 2014). This highlights the importance of developing methods that allow natural rodent behaviour whilst minimising economic loss.

Non-lethal methods such as deterrent paints, chemical repellents, plastic tubing, and chicken wire have been widely employed in Europe and North America to safeguard economically productive landscapes against rodent activity (Baer 1980, Gaywood 2017, Larson et al. 1979). These methods provide a physical or chemical barrier to either deter or completely prevent rodents from harvesting trees. Nonetheless, there are existing installation issues; wire cylinders that use chicken wire or similar materials may inhibit stem growth and increase the need for frequent adjustment to reduce stem damage (Van Lerberghe 2015). So whilst the use of chicken wire may be appropriate for small-scale plantings and gardens, it is unlikely to be suitable for large-scale commercial forestry (Marsh et al. 1990). Tree guards, which use galvanised steel, or plastic netting have so far been widely employed to

mitigate animal damage to trees (Marsh et al. 1990). However, the preventative effectiveness against rodents of more robust materials, such as stainless steel, that provide long-term durability and corrosion resistance so far remains unclear (Ding 2024).

Beavers (*Castor* spp.) are responsible for much of the large-scale changes in the riparian zone (Rosell and Campbell-Palmer 2022). Their tree felling behaviour differs fundamentally from most other rodent species, given their ability to fell not just saplings but also fully mature trees (Voelker and Dooley 2008). Furthermore, beavers typically fell trees higher up the stem at a preferred cutting height between 4–50 cm (Skøyen et al. 2018; Wilsson 1971). There are two extant species of beaver, the Eurasian beaver (*C. fiber*) and the North American beaver (*C. canadensis*), that share both morphological and behavioural similarities (Rosell and Campbell-Palmer 2022). A study attributed North American beavers to harvesting an average of 1400 kilograms per hectare per year of woody biomass over a 6-year foraging period (Johnston and Naiman 1990). Beaver foraging activity follows strict temporal patterns; with autumn generally displaying peak rates of activity in tree felling (Lodberg-Holm et al. 2022). Most of this material is used to construct dams and lodges, but saplings and shrubs are also harvested as an immediate food source or stored in food caches for winter preparation (Rosell and Campbell-Palmer 2022). Therefore, tree guard performance may vary seasonally, particularly in riparian zones within < 20 m of the riverbank where human-beaver conflict and beaver damage is most likely to occur (Nolet and Rosell 1998, Schwab and Schmidbauer 2003). By implementing effective mitigation strategies such as stone or mesh embankment reinforcements, the introduction of exclusion zones and guard mesh, these conflicts can be reduced (Rosell and Campbell-Palmer 2022). Despite these mitigation strategies, there are no empirical studies that have tested their effectiveness in the protection of trees against Eurasian beavers.

Only one study has systematically reviewed the effectiveness of tree guards against foraging behaviour of beavers. A study in Saskatchewan County, Canada reviewed and compared the effectiveness of four different types of tree guards on preventing tree damage by North American beavers (Westbrook and England 2022). Their study largely focused on beaver prevention methods in urban environments, where ecological conditions differ greatly from those in agricultural and riparian zones. The lack of control variables such as protected vs unprotected trees, leaves a need for experimental design with clearly defined controls.

We investigated this using a novel stainless steel guard mesh over the autumn season, where beaver foraging intensity peaks. We hypothesise that stainless steel guard meshes will prevent beavers from felling protected trees. We predict that: (1) trees protected with a guard mesh will experience lower rates of beaver felling than unprotected trees; (2) if felling does occur, protected trees will take more time to be felled than unprotected trees and finally that (3) guard mesh effectiveness will depend on installation height, with height influencing the behavioural methods beavers use to fell trees.

Methods

Site selection and study design

Sites were selected by considering proximity to signs of recent beaver activity. Ideal planting locations were close to beaver scent mounds, feeding trails, bankside burrows and evidence of gnawing on woody material (Campbell-Palmer et al. 2021). Sites were also selected carefully to avoid human disturbance (e.g. minimising proximity to recreation areas, jetties and public footpaths) and ensuring appropriate soil conditions (e.g. wet soil suitable for tree planting). Furthermore, all sites are within beaver territories that have been monitored, long-term, by the Norwegian Beaver Project (Lodberg-Holm et al. 2022; Rosell et al. 2025). To maximise frequency of beaver visits, trees were also planted at territory borders where especially the dominant pair are actively scent marking (Rosell and Thomsen 2006). All GPS coordinates were recorded with a handheld GPS device and landowners' permission was sought before planting. We conducted our experiment in two phases, using two different tree species: apple trees (*Malus domestica*) and aspen branches. Apple trees were selected since they represent a high value crop tree that provide economic benefits to the region surrounding our study area. The surrounding areas of both study sites are one of the largest producers of apples in Norway, with approximately 4000 Ha of land dedicated to fruit production (Midt-Telemark kommune, 2026). After the initial apple tree experiment, it became clear low canopy height on the saplings limited how high the mesh could be wrapped around the stem. To conduct the experiment with adherence to recommended installation protocol, aspen branches were selected for a follow-up experiment, since they allow for higher guard mesh placement and still represent desirable forage for beavers (Bennett et al. 2019).

A total of 76 individual trees were monitored, including 38 matched pairs. We first planted 19 pairs (one with guard mesh and one without) of apple trees and then 18 pairs of aspen branches along the banks of both rivers. All apple trees were purchased from a commercial tree nursery, Baldishol Nursery AS (<https://baldisholplanter.no>). Aspen branches were harvested with a handsaw from a forest outside of the study area, where no prior beaver foraging had been recorded. The aspen tree was approximately 4–5 m. Before planting, all trees were paired by size, i.e. we considered the number of branches of each tree, height and trunk diameter to select as similar trees as possible for each experimental location. Apple trees were planted between 19th August and 24th September 2025, whilst aspen branches were planted between 29th October and 19th November 2025. All trees and branches were installed during the daytime. A random number generator determined whether the mesh covered tree would be planted on the left or right of each planting location. We ensured that trees were planted at an equal distance from any signs of active beaver activity, such as scent mounds or trails. Each pair was made accessible for beavers for 30 days. At each location, all trees and branches were planted 96.8 ± 24.2 (SD) cm from each other with variation due to uneven or rocky ground. Apple trees were planted with their roots intact at a soil depth of 30 cm and on the riverbank 175.7 ± 196.2 SD cm from the river edge, with variation due to steep banks and flooded ground prohibiting planting at the water line in some locations. We tied two Norwegian Discovery apples to each apple tree on their lower most branches using a cotton twine to simulate fruiting. Two handfuls of chicken manure were added to each planting hole as fertilizer for the apple trees. For the aspen branches, due to lack of intact roots, all planting holes were bored using a screwdriver drill. Branches were then stabilised with kindling, to prevent beavers and other non-target species from pushing them over. Planting holes for aspen branches were 211.5 ± 202.7 SD cm from the

river edge. Distance to water differed between apple trees and aspen branches due to the addition of some new locations used during the 2nd experiment. This was to mitigate flooding of apple tree planting locations during the autumn in the Gvarv river.

Study area

We carried out our study on two rivers in Midt-Telemark and Nome municipalities, Telemark County, southeastern Norway: a 5 km stretch of the Gvarv river (59.38780, 9.17467) and a 6 km stretch of the Straumen river (59.30416, 9.10244). The Straumen river is characterised by adjacent arable land, with extensive tree coverage on both banks of the river (Rosell et al. 2025). The Gvarv river also borders arable land, whilst some of the land adjacent to the river is privately owned, ornamental lawns and public recreation areas. Dominant tree species in each river include both deciduous and coniferous species, including: Scots pine (*Pinus sylvestris*), ash (*Fraxinus excelsior*), alder (*Alnus glutinosa*), willow (*Salix spp.*), aspen (*Populus tremula*) and silver birch (*Betula pendula*) (Haarberg and Rosell 2006). The average Eurasian beaver family in the area consist of 4.0 ± 1.9 SD individuals, whilst the average size of beaver territories is 3.3 ± 1.5 SD km (Mayer et al. 2020, Rosell et al. 2025)

Experimental set-up

The guard mesh, produced by Frukt As (<https://www.frukt.as>), is made from 0.26 mm stainless-steel wire and knitted into a mesh with an aperture of approximately 10 mm. Unlike chicken wire, which is usually non-stretchy and made from galvanised steel, the stainless-steel mesh is unique in its stretch, durability, rust resistance and ability to protect the tree throughout its lifespan with minimal adjustment. The height in which guard mesh was placed on the apple trees, differed according to canopy height. Apple trees were guarded to 58.5 ± 7.5 SD cm height from the base of the trunk (Fig. S1). Aspen branches were guarded to a standardised 120 cm consistent with guidelines from Pollock et al. (2017), which recommends guards extend 3–4 feet (91–122 cm) from the ground. To accommodate the steel mesh, any aspen branches below 120 cm were cut off with a handsaw, low canopy height meant apple trees were unable to accommodate the steel mesh at this height. Aspen branches had a mean stem diameter of 2.3 ± 1.3 SD cm and a mean height of 247.4 ± 61.3 SD cm. Apple trees measured between 120–180 cm in height. The mesh was measured to 250 cm x 100 cm before installation and then wrapped continuously from the bottom of the stem, up to a marked line at 120 cm. Metal wire was used as needed to secure the outside of the mesh to prevent unravelling. Rove Viltvakt trail cameras (Model number: DL006-1) were installed behind planting locations approximately 1 m above the ground and 3 m behind each pair of trees, facing outwards towards the river ensuring the whole of the tree stem was visible in recordings. The date and time on each camera were set, and each unit was programmed in video mode and recorded at 1080p resolution. The cameras were equipped with a 10 m motion sensor, 940 nm IR and recorded at a minimum of 5 s intervals between recordings to ensure capture of visitor interactions at each site. Each camera had 4 AA 1.5 V batteries and was loaded with a 32GB SD card.

Cameras were used to monitor time to felling and behavioural responses of beavers and other non-target species to apple trees and aspen branches (Fig. 1).

Monitoring design

Camera traps remained in place at each site until either both trees were felled or until the end of the study period (30 days after planting). SD cards were downloaded once from cameras when the study period elapsed. We recorded whether cuts were made above or at the bottom of the mesh for all trees that were felled. Additionally, we estimated the age groups of beavers (adults, yearlings and kits) that were recorded felling trees, by comparing the relative body sizes of all beavers present at a planting location. Weight classes of Eurasian beavers, in late summer months, are approximately 15–25 kg for adults, 8–14 kg for yearlings and 2–4 kg for kits (Rosell et al. 2006). If only one beaver was recorded at a location, age classes were estimated by comparing with frames from other camera traps, however this was not always possible to compare, and therefore not all beavers could be assigned to an age class (Viviano et al. 2026). Finally, using camera traps, we also registered non-target species that interacted with planting locations.

Data analysis

We conducted three separate analyses to estimate 1) the difference in felling rates by beavers of protected vs unprotected trees, 2) the difference in time to felling of protected vs unprotected trees, and 3) how guard height influences the behaviour of beavers at each treatment. Consecutive videos of animals interacting with the same trees within a short timeframe were merged. Each animal observation and behaviour was therefore only counted once per visit to each location. Since both pushing and gnawing behaviours led to felling, these two behaviours were merged in statistical analyses. As samples are within matched pairs, McNemar's Chi-squared test was used to estimate felling outcomes between guarded and unguarded trees. We also compared the time that it took to fell all guarded trees and control trees using a stratified log rank test, within the 'survival package' in R (Therneau, 2024). Kaplan – Meier curves were produced in R to compare the survival times of both unguarded and guarded, apple trees and aspen branches. Remaining apple trees at the end of the study period were classed as surviving for 720 hours (the total duration of time from initial planting to the end of the study period, i.e. 30 days). For the aspen trees that were planted later in the year, colder temperatures caused some camera malfunctioning, and beaver felling could therefore not be estimated to the hour. Any pairs that contained a tree whose felling time could not be estimated, due to camera trap fault, were excluded from the survival analysis. Excluded pairs were, however, included in felling outcome analysis as this was recorded for all locations at the end of the study period. All statistical analyses were conducted in RStudio with R version: 4.4.1 (R Studio 2026)

Results

Beavers visited, at least once, 14 of the apple tree planting locations and 14 of the aspen tree location, 4 sites of both species were never visited by beavers.

Felling frequency and survival

Of 38 apple trees, 30 were felled by beavers during the study period. Of these, 15 were guarded and 15 unguarded. Conversely, of 36 aspen branches, 18 were felled in total, 16 unguarded and 2 guarded. Among the aspen branches remained standing at the end of the study period, 17 of these were guarded. Unguarded aspen branches were felled significantly more often than guarded branches ($\chi^2 = 11.077$, $df = 1$, $p = 0.001$). When comparing felling outcomes between species and treatments, a significantly higher proportion of apple trees were felled when compared with aspen branches ($\chi^2 = 6.8423$, $df = 1$, $p = 0.009$). Proportionally, 78.9% of all apple trees were felled in contrast to 50.0% of all aspen branches (Fig. 2) (Table 1). The median time to felling was 168 hours (95% CI: lower bound: 108 hours) for unguarded apple trees and 254 hours (95% CI lower bound: 132 hours) for guarded apple trees (Fig. S2). When comparing survival distributions, no statistically significant difference within matched pairs was found ($\chi^2 = 1$, $df = 1$, $p = 0.300$). The median time to felling of unguarded aspen branches was 9 days (95% CI: lower bound: 1 day) (Fig. S3). All guarded branches where time to felling could be calculated ($n = 18$) remained standing at the end of the study period (30 days). Guarded branches had a significantly longer survival time, compared with unguarded branches ($\chi^2 = 13$, $df = 1$, $p = 0.0003$).

Table 1

A summary of the number of apple trees (*Malus domestica*) and aspen branches (*Populus tremula*) felled by beavers between 19th August and 19th November 2025, across both guarded and unguarded treatments in both the Straumen river and the Gvarv river, Midt-Telemark, Norway.

Species	Treatment	No. of trees	No. of trees felled	Total felled (%)
Apple trees	Guarded	19	15	78.9
	Unguarded	19	15	78.9
	Total	38	30	78.9
Aspen	Guarded	18	2	11.1
	Unguarded	18	16	88.9
	Total	36	18	50

Behavioural observations

The camera traps contained 39 videos of beavers engaging with the apple trees but only 11 of engagement with aspen trees. Due to colder temperatures during the aspen experiment, the camera regularly malfunctioned, which meant most behavioural observations were made of beavers interacting

with apple trees. Typical beaver behaviours, when encountering the guarded apple tree, followed a set procedure of sniffing of the tree or guard mesh, before raising onto hind legs for further inspection and engaging in gnawing attempts (Fig. 3). This was often accompanied by pushing the branches and stem of both guarded and unguarded trees to get better access (Fig. 3). When encountering apple trees, felling was the most recorded behaviour with observations recorded at 44.4% of guarded trees and 50.0% of unguarded trees (Fig. 4). The second most common behaviour was sniffing with observations at 38.9% of guarded trees and 22.2% of unguarded trees. In the unguarded trees, sniffing was accompanied by a gnawing attempt (22.2%), but the guarded apple trees had slightly fewer gnawing attempts (16.7%). The beavers more often attempted to push over the guarded apple trees than the unguarded trees (27.8% and 5.6%, respectively) (Fig. 4). The few videos from beavers interacting with the aspen trees revealed repeated gnawing attempts made on guarded aspen branches that were eventually abandoned. Beavers were also not successful in pushing the aspen branches over as they were inserted deeper into the ground than the apple trees. There was some variation of beaver ages recorded from the camera traps when felling apple and aspen trees. Where age could be estimated (50% of locations), most observations were adults (73.7%), followed by yearlings (21.1%) and one kit (5.3%). A variety of behaviours by non-target mammals was also observed, including sniffing behaviour on and around the trees by mustelids, cervids, equids, and canids (Fig. S4). Pine martens (*Martes martes*) were observed eating apples from the apple trees (Fig. S5). Felling of trees by species other than beavers was not recorded.

Discussion

Our results partially support our hypothesis that the stainless-steel guard meshes reduce beaver felling of trees. The first prediction, that tree guards would reduce felling was partly supported. This was especially evident for the aspen branches, which were felled significantly less when protected. However, felling rates remained high across both guarded and unguarded apple trees due to the protective mesh not being installed high enough. Our second prediction was also supported, unprotected aspen branches were felled within the first week of the study, whilst significantly more guarded aspen branches stayed standing throughout the study. Survival trends also revealed a delayed effect of guarded apple trees being felled after their unguarded counterparts. Our third prediction stated that the effectiveness of guards was dependent on installation height, which was reflected in behavioural observations showing beavers overcoming the guards installed at a lower height. Behaviours to overcome tree guards were observed in the apple trees but not aspen branches where all tree guards were installed at 120 cm.

Felling frequency and time to felling

In our study, felling frequencies were revealed to be highly installation specific, indicating that the presence of guard mesh alone does not prevent felling, but that protection relies on preventing beavers from accessing preferential cutting points. In the young apple trees, installation of the guard to the recommended 120 cm was not possible without damaging the lower canopy. This resulted in guarded aspen branches being significantly less likely to be felled by beavers, but guarded apple trees not being

significantly less likely to be felled than the unguarded aspen trees. An additional challenge with the apple trees was the recent planting where the roots had not yet established in the ground, which meant that beavers, aided by the lower branches, could easily pull the tree over. Whereas in aspen branches, the guard mesh consistently prevented beavers from chewing through the stem, and no lower branches were available for beavers to use as a leverage point as the stems were placed deeper into the ground. In some instances, there was evidence of prioritisation of alternative forage and apple trees were left standing. Furthermore, evidence of apple trees being ignored for alternative forage suggest guard-meshes can be deployed strategically to maximise deterrence whilst remaining cost effective. For example, desirable alternative forage such as poplars (*Populus* spp.) and willows (*Salix* spp.) can be planted alongside key ecological and economic assets that are protected with a guard-mesh (Mikulka et al. 2022). A wider forested buffer zone has also been shown to discourage beaver foraging on cereal fields (Lodberg-Holm et al. 2022). Taking this mixed approach provides a food resource for rodents, whilst minimising economic losses from sapling damage, caused by rodent foraging behaviour (Huitu et al. 2009; Suchomel et al. 2019). On the other hand, complete removal of preferred forage species is unlikely to deter rodents from utilising an area and can lead to swifter felling of trees. This has been demonstrated in beavers, who will use a landscape regardless of forage availability (Rosell and Campbell-Palmer 2022).

When considering the time until felling, significantly more unprotected apple trees and aspen branches were felled within the first week of the study compared to their guarded counterparts. This trend was particularly clear in aspen branches, where significantly more guarded branches stayed standing throughout the study. However, also in the apple trees there was a trend of guarded trees being felled after their unguarded counterparts, despite an equal number of trees from each treatment group remaining standing at the end of the study. This pattern is also consistent with optimal foraging theory that predicts rodents will forage in a way that optimises energy intake whilst minimising the risk of gathering food (MacArthur and Pianka 1966). In our study, mesh guards increased handling time of the beavers, to where the energetic cost of felling was more than the caloric reward of the tree, and so unguarded trees were felled first whilst before felling of the guarded trees were attempted (Gallant et al. 2004). Our study took place over a short time, in the autumn, where beaver foraging intensity is at its annual peak as beavers are building up their winter food caches (Busher et al. 2020, Lodberg-Holm et al. 2022). The rapid felling of unguarded trees and branches, especially aspen trees, may be reflective of heightened foraging pressure. Our study was only short term, and we can only make limited inferences about the effectiveness of a stainless-steel guard mesh during autumn time. A Polish study found, however, that most damage caused by flooding and cutting of tree stands occurred during the spring and summer months (Janiszewski and Hermanowska 2019). This highlights the need for a year-round experiment to test how seasonality influences guard effectiveness against rodents under varied foraging pressure and over longer time frames.

Guard height implications and behavioural observations

Our findings revealed that the stainless-steel guard mesh can greatly reduce felling rates, but only when installed at heights that block access to preferred cutting points. This was achievable in the aspen branches but not in younger, smaller apple trees without damaging the canopy. Our apple tree and aspen branch experiments can add to existing installation protocol and recommendation consensus. We found that tree guard meshes were most effective when installed at 120 cm height (Pollock et al. 2017). This is consistent with results from Westbrook and England (2022) that found a negative relationship between guard height and damage frequency. Beavers show preferential cutting height to be between 4–50 cm (Skøyen et al. 2018; Wilsson 1971). However, on apple trees, guards were installed at a lower height due to low canopy height restrictions, which allowed beavers to cut above the mesh.. Beavers pushed some apple trees over by grabbing the stems. This was likely due to lower stem diameters of apple trees and the planting methods which increased malleability enabling beavers to overcome the protective effects of the guard. Aspen branches were placed deeper into the ground, and we recorded no instances of beavers successfully pushing over these branches. We can therefore not conclude that the tree would not be efficient even at lower installation heights if apple trees were more stabilized with proper roots. Nonetheless, low canopy restrictions are inevitable in saplings and so, alternative protections strategies such as complete fencing off from the area should be carried out to ensure protection during the early growth phase (Nolte et al. 2003). As optimal apple tree height for productive apple trees is around 2.75–3.25 m, future studies should investigate whether stainless-steel guards can be applied higher up in mature apple trees without damaging parts of the canopy vital for apple production (Callesen 1993).

Mechanisms of tree protection

The behavioural observations revealed that beavers often attempted to gnaw on the tree guards, but we had no instances of beavers successfully chewing through the tree guard. Additionally, there was no observed damage to recovered tree guards by beavers. Other than one instance of felling of an unguarded apple tree by a kit and four pairs felled by sub-adults, most trees and branches were felled by adults, which have been recorded to have an impressive biting force of between 550–740 Newtons (Rosell and Campbell-Palmer 2022). This suggests that when properly covered by guard mesh, beavers will not be able to bite through. Properties of stainless-steel, such as corrosion resistance, high tensile strength and overall durability could explain the pattern of unsuccessful repeated gnawing attempts and exploratory behaviour by beavers on guarded aspen branches (Ding 2024). Additionally, the novel construction includes a 3D structure with low aperture and a knitted design that results in a high-stretch material with less likelihood of constricting future tree growth. This flexibility could reduce the user's labour cost and time, as the mesh need only be readjusted periodically. This is unlike existing galvanised steel materials that are commonly used, such as wire cylinders (Marsh et al. 1990). While the material tested in this study was originally developed to protect tree routes from smaller rodents foraging on underground roots, we found it has great potential to also be expanded to tree stems above ground and larger rodent species such as beavers if applied correctly to the trees.

Conclusion

Rodents make physical alterations to their environment, and in doing so play a fundamental role in maintaining healthy ecosystems. Through nutrient enrichment, increasing food source availability and seed dispersal, rodents enrich the ecological niches in which they occupy (Glaudas et al. 2008, Sirotnak and Huntly 2000, Lessa et al. 2019). Beavers provide one of the best examples of how physical alterations to their environment can increase biodiversity and habitat quality. Whilst these services are being increasingly recognised as valuable tools for habitat restoration, beaver behaviour such as tree felling does not always align with human interests. Our study revealed that our novel stainless-steel guard mesh can significantly reduce felling, but only when installed with adherence to appropriate installation protocol and at heights that prevent beavers from accessing canopy features. Following our protocol will help managers who wants to protect valuable economic and ecological resources from beaver damage. However, we only studied the tree guard short-term effectiveness to prevent beaver foraging and as a next step we suggest a long-term study to assess how the guard will both protect trees across different seasons and expand with the tree over time while retaining its protective qualities.

Declarations

Competing Interests

Authors declare that there is no conflict of interest.

Ethical Approval

Ethical committees within the Norwegian Food Safety Authority (most recent authorization FOTS ID 2025/22962) and the Norwegian Directorate for Nature Management (most recent authorization 2025/8730) approved the study of beavers in the study area, and the fieldwork was conducted with permission from the local landowners.

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Author Contribution

All authors developed the study design. DP and CR collected the data, DP performed the statistical analyses with help of HKLM and FR, and DP wrote the first draft of the manuscript with support of FR and HKLH. All authors approved the final manuscript.

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Data Availability

The data are available upon request.

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Figures



Figure 1

Experimental set-up of matched pairs of apple trees with Norwegian Discovery apples (*Malus domestica*) planted with intact roots by the Gvarv river and Straumen river, Midt-Telemark, southeastern Norway, 2025. One tree was protected with a stainless-steel guard mesh and the other without (control). The trail camera was elevated behind the apple tree saplings and faced towards the river. Apples were tied onto the canopy using a cotton twine.

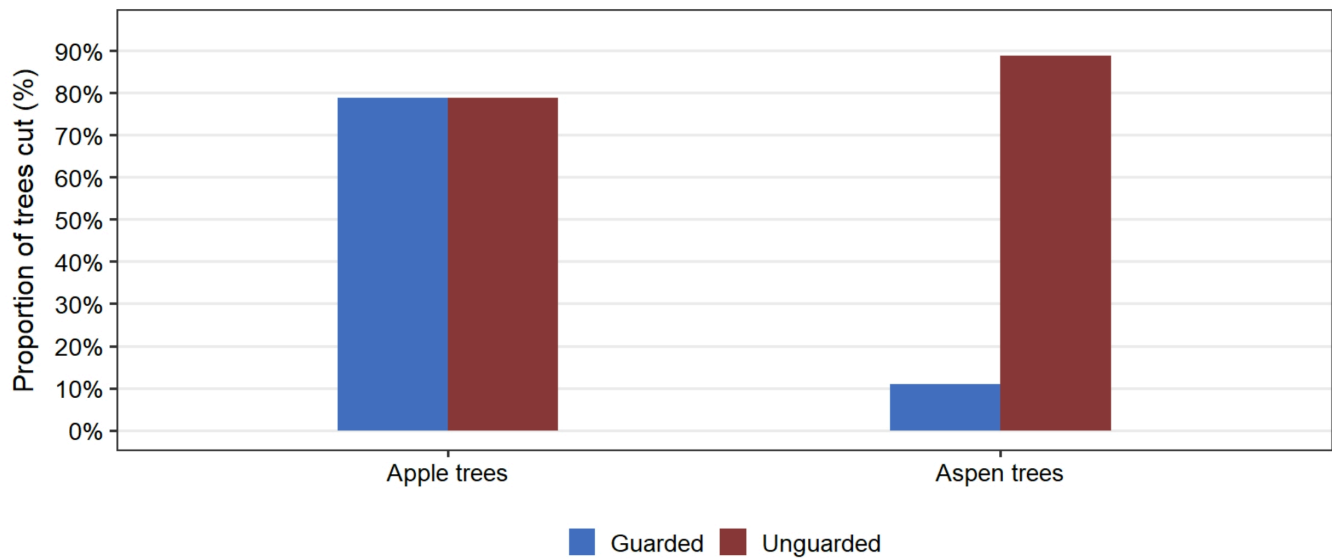


Figure 2

The proportion of apple trees (*Malus domestica*) and aspen branches (*Populus tremula*) felled by Eurasian beavers (*Castor fiber*) between 19th august and 19th December, 2025, across guarded and unguarded treatments in both the Straumen river and Gvarv river, Midt-Telemark, southeastern Norway.



Figure 3

Camera trap pictures to illustrate common Eurasian beaver (*Castor fiber*) behaviours encountering protected aspen branches and apple trees; (a) sniffing at the base of a guarded aspen branch, (b) pushing of a guarded apple tree, (c) gnawing attempt at a stainless-steel guard mesh, and (d) felling of a guarded apple tree above the mesh.

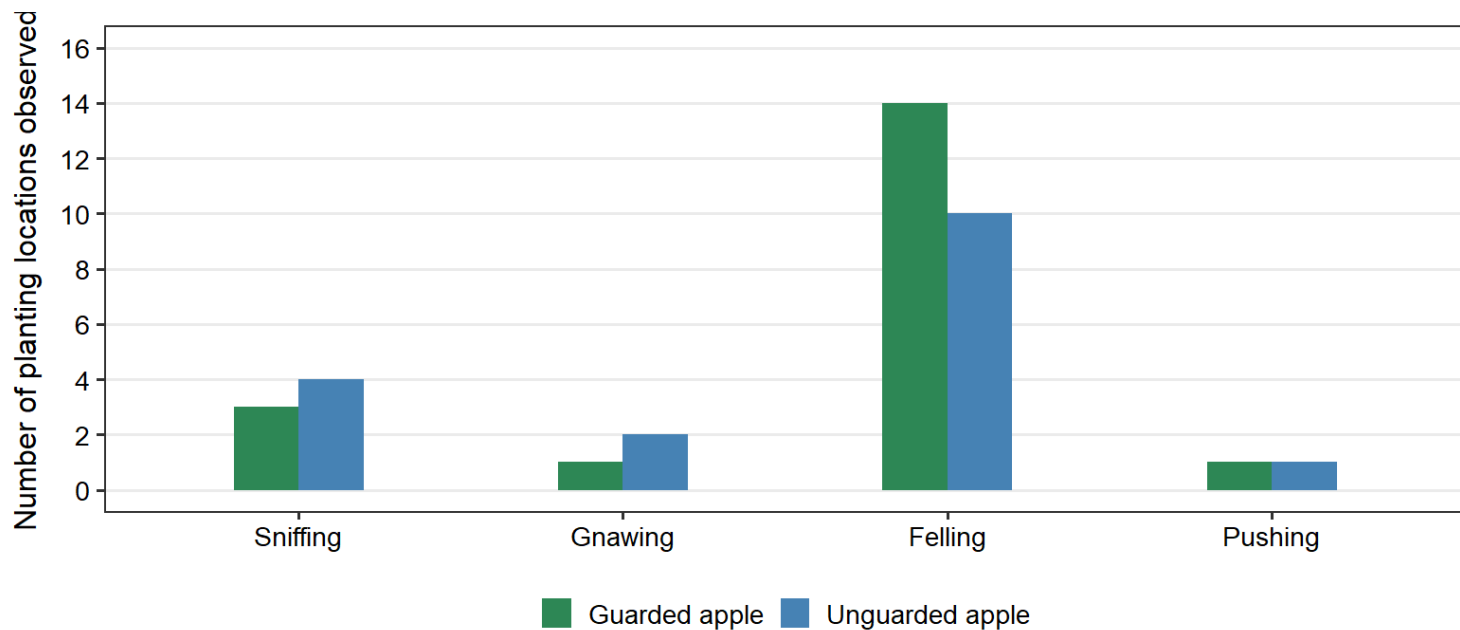


Figure 4

Total number of apple trees where each behaviour type was observed (sniffing, gnawing, felling and pushing), performed by Eurasian beavers across both guarded and unguarded apple trees in the Gvarv river and Straumen rivers in 2025, Midt-Telemark, southeastern Norway.

Supplementary Files

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