Protecting trees from wildlife damage – Mesh tree guards

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- Types of damage caused by wildlife
- Methods for identifying the animals responsible
- Choosing the best type of protection
- Installation techniques

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Introduction

In the 1960s, damage by wild animals did not seem to be a problem for foresters, as wildlife population densities did not exceed the carrying capacity of forests. Nowadays, many woodlands, as well as farmlands, are experiencing uncontrolled wildlife population explosions. Wildlife most certainly has a legitimate and necessary place in the ecosystem, but the biological equilibrium of forests and fields is increasingly threatened by the demographic and geographic expansion of populations of certain animal species.

There is no magic recipe for reconciling efficient forestry with the presence of wildlife in forests and fields. Instead, we have a series of more or less partial measures that have to be adapted as well as possible to each individual situation.

Looking beyond today's fierce controversies over the balance between forests, farmlands and wildlife, this technical guide reviews current knowledge on damage to trees caused by certain wild animals (rabbits, hares, roe deer and red deer) and provides a detailed description of one of the main methods currently in use to protect individual trees directly from animal damage: mesh tree guards.

The guide describes all the possible types of damage to trees caused by these animals, as well as criteria for identifying them in the field. The aim is to help foresters to correctly identify the animal responsible for the damage and therefore to choose the best type of protection.

The wide range of products on the market requires foresters and agroforestry managers to understand their different technical properties and quality criteria so that they can choose the type of tree guard that best meets their needs.

The effectiveness of mesh tree guards essentially depends on their durability and resistance to wind, and on the techniques used to install them. The guide provides clear illustrations of the different types of mesh tree guards and supports, with recommendations on their quality.

This is a technical guide designed to help aspiring foresters to minimize the costs of protecting their future plantations and naturally regenerating forests from potential damage by wildlife. We advise (agro)foresters wanting to protect their trees to read about the solutions proposed here before putting them into practice.

We hope you will find this guide both useful and enjoyable.

Table 1 - Types of damage to woody plants and crops caused by deer, hares and rabbits

CROP	ORIGIN	TYPE	PERIOD	PLANTS OR PLANT PARTS AFFECTED	ANIMALS INVOLVED
FORESTS					
Trees and shrubs	Feeding	Browsing	Autumn, winter	Seeds (acorns, beechnuts, chestnuts, hazelnuts, etc.)	Deer
			Spring	Seedlings	Deer
					Hares and rabbits
			No sap flow	Buds, tips of woody shoots	Roe deer (deciduous hardwoods and evergreen conifers)
					Red deer (esp. evergreen conifers)
					Hares and rabbits
			Sap flow	Buds, tender green shoots, leaves	Roe deer (esp. deciduous hardwoods)
					Red deer (esp. deciduous hardwoods and larches)
					Hares and rabbits
		Bark gnawing	No sap flow	Trunks of young trees	Hares and rabbits
	Behavioural	Buck rub (antlers)	February to May	Flexible trunk (main shoot) of young trees	Roe deer
			Mid-July to mid-September		Red deer
		Buck rub (rutting season)	Mid-July to mid-August		Roe deer
			September - October (bugling)		Red deer
	Both	Bark stripping	Winter, summer	Bark with little or no suberisation	Red deer
CROPS[1]					
Grain crops	Feeding	Grazing	Growth stages before ear formation (germination to stem elongation stage)	Browsed stalks and leaves of winter cereals	Red deer
		Close grazing		Browsed stalks of winter cereals (wheat, oats)	Rabbits
		Cut stalks			Hares
		Stripping ears and cobs	Grain ripening stage	Browsed ears of unbearded cereals (soft wheat, oats)	Red deer
Maize	Feeding	Grazing	Growth stages before ear formation (germination to stem elongation stage)	Stalks and leaves browsed. Leaving stumps to a height of 30 to 80 cm	Red deer
				Stalks cut along grazing front	Rabbits
		Stripping ears and cobs	Grain ripening	Ears partially (2/3) consumed. Stalks not broken	Red deer
Winter rape	Feeding	Foraging	Rosette stage (late autumn - winter)	Browsed stems and leaves	Red deer, roe deer
Pulses (field beans and peas)	Feeding	Foraging (late Autumn - winter)	Germination (from first leaves)	Browsed stems and leaves	Rabbits, hares
		Grazing (spring)			
Potato	Behavioural	Trampling	Tuber formation	Earthed-up rows trampled and plants crushed	Red deer
Beet	Feeding	Browsing and/or gnawing at the root collar	Summer, Autumn	Leaves browsed. Above-ground portions of roots damaged.	Red deer, roe deer
				Above-ground portions of roots damaged	Rabbits, hares
Meadows	Feeding	Browse patches used by deer	Mainly winter and spring	Browsing in meadows along woodland edges	Red deer, roe deer

(1) Damage to crops can be significant. It is mentioned here for information only and not discussed in detail.

Wildlife damage to trees and shrubs

Wildlife is integral to the life of forests and fields, and it is therefore normal for animals to feed there and leave signs of their presence. As they seek to satisfy their natural needs (food and reproduction), animals can cause damage to their environment, ranging from a few minor depredations associated with normal animal life to severe ecological and/or economic damage that reflects an overall imbalance.

What is damage?

Definition

Forests and woodlands, wooded strips, copses, hedgerows and isolated trees are important and often complementary sources of a wide variety of timber products and fruits:

- lumber (carpentry, sawmills) and utility wood (posts, stakes, poles), industrial wood (paper, pulp) and fuelwood (logs and woodchips);
- timber by-products: stem wood chips for mulching trees and shrubs; chipped branches used as an organic amendment for enriching the carbon content of agricultural soils;
- fleshy fruits (apples, pears, cherries, olives, etc.) or dry fruits (acorns, beechnuts, chestnuts, walnuts, hazelnuts, etc.) for human and animal consumption.

Woodlands and hedgerows also help to improve grassland quality and crop yields by acting as windbreaks. Trees add organic matter to the soil through the year-on-year decomposition of fine roots and leaf litter. They also help, directly or indirectly, to protect livestock and their health.

By mitigating adverse climatic effects and improving soil quality, trees help to maximise the overall potential of fields or meadows and contribute significantly to improved agricultural production.


1

Impacts of wildlife on these various crops are referred to as damage, i.e., *"any action by animals that, through their presence, feeding, and/or behaviour, reduces the quantity or quality of the current or future yield of a timber or agricultural crop"*.

Risk factors

The vulnerability of crops and the intensity of damage depend on several environmental factors:

- the size of the animal population: when hunting no longer regulates the interactions between wild animals and their biotope, their demographic and geographical expansion can lead to overexploitation of resources and increase the frequency of damage;
- existing food resources for animals, determined by the natural richness of the forest and field environment and the type and abundance of nearby crops;
- the attractiveness to animals of a given plant species at a given growth stage (palatability);

2

3

4

- weather conditions causing food scarcity in forests in winter or in lowlands during summer droughts;
- the presence of refuges and cover where deer on the run can hole up for several days during the hunting season;
- human activities (on-road and off-road traffic, hunting, logging) that cause stress to animals. These disturbances can cause gregarious species such as deer to mark their territories by rubbing trees or stripping bark.

Types of damage

Cervids (roe deer and red deer) and leporids (rabbits and hares) damage trees in various ways **(Tableau 1, p.5)**.

Damage may be related to feeding and/or behaviour and its appearance provides clues as to the species responsible.

Damage can be due to browsing (removal and consumption of young shoots), rubbing (male deer rubbing their antlers on tree trunks), bark stripping (red deer feeding on bark), and bark gnawing (nibbling on bark by rabbits and hares).

Although browsing is the main cause of animal damage to woody plants, bark stripping and rubbing, which are exclusively the work of wild ungulates, can also cause significant damage locally.

1 - The distinct bevelled cut on this stem shows that it was browsed by a rabbit.

2 - This locust sapling was rubbed by a roe deer during the rutting season.

3 - The teeth marks on the trunk of this Douglas fir are characteristic of winter bark stripping.

4 - Bark girdling by rabbits rapidly leads to the death of the tree.

Definition

BROWSING

Browsing **(Photo 1)** refers to the removal and consumption of seeds, seedlings, buds, leaves or needles, vertical shoots or lateral branches of woody undergrowth, natural regrowth, or artificial plantations in forests and fields.

Animals use their teeth to detach the palatable parts of plants within their reach. They may eat entire shrubs (leaves, branches, bark) and sometimes pull up or snap young seedlings.

Deer, rabbits and hares all cause this type of damage, which is mainly feeding-related as they seek to supplement their diet of herbaceous and semi-woody vegetation.

RUBBING

Rubs are wounds inflicted on the bark of trunks and stems of young trees for purposes other than feeding **(Photo 2)**. Bark is torn; trunks are stripped to varying degrees and sometimes even snapped. This type of damage, caused by male deer, mainly affects young trees (less than 10 years old) and usually leads to the death of the damaged tree.

The causes of rubbing are essentially behavioural. Male roe deer and red deer use tree trunks to rub off the velvet from their newly acquired antler growth when it starts to shed. During the rutting period, they search for mates and engage in mock combat against young trees and shrubs to release their aggression and mark their territory with scent signals.

BARK STRIPPING

This refers to any wounds caused by red deer when they use their teeth to detach pieces of bark that are then entirely consumed. The damage is often concentrated and mainly affects trees with thin bark and relatively high-set branches.

As there is no sap flow in the bark during winter, it adheres firmly to the trunk. The animal has to scrape the trunk with its teeth to detach the bark, leaving clearly visible teeth marks **(Photo 3)**.

In the spring and summer during sap flow, bark is easily detached and red deer tear it off in strips. This can cause rot or discolouration of the wood, thus reducing its market value.

The causes of this type of damage, which is related to both feeding and behaviour, are complex and not clearly understood, but clearly complementary: need for roughage (lignin) to improve rumen function, quenching thirst during severe winters or prolonged droughts, excessive stress in animals made nervous by hikers or hunters.

BARK GNAWING

This type of feeding-related damage is caused by rabbits and hares. It is closely correlated with food scarcity and with the animals' need to wear down their incisors.

It consists of bark nibbling and is often characterised by oblique teeth marks at the collar or base of the trunk of young trees **(Photo 4)**.

Consequences for woody plants

Injuries to woody plants can have many different consequences, both quantitative and qualitative, which are exacerbated by accumulation.

The reaction of the tree depends on its height, age and vigour, on the species, the time of year, and the frequency and severity of the injuries.

The main consequences **(tableau 2)** are:

- loss of viable trees and sometimes complete destruction of natural regeneration or artificial plantations (browsing, rubbing);
- need for restoration work (fill planting in damaged plantations, replacement of destroyed tree guards or possibly installation of overall protection), closer surveillance of plots, all resulting in additional investment costs;
- growth deformations or retardation giving rise to additional costs for corrective pruning (of browsed trees);
- partial or total loss of production (volume) and lower quality and price per cubic metre of wood (products unfit for marketing, e.g. when the butt log is damaged by bark stripping or rubbing) causing a shortfall in earnings;
- when animals prefer certain species over others, this can change the species composition of a forest as they eliminate certain plant species (loss of biodiversity), which can favour other rarely browsed or more resistant species (as in the case of spruces dominating firs, or beeches dominating oaks). Species that are generally highly palatable (ash, cherry, maple, mountain ash) disappear most often.

Table 2 - Consequences of wildlife damage for tree mortality, growth, and shape

DAMAGE	PART ATTACKED	FREQUENCY OR INTENSITY	CRITERION	CONSEQUENCE
Browsing (Deer)	Leader (determines height growth and the future shape of the tree)	Once or twice	Shape	Loss of apical dominance and lower technical quality in the case of forks (irregular shape) formed by replacement shoots or upward growth of several upper lateral shoots.
			Growth	Retarded aerial growth (esp. in conifers, which store their reserves in their old needles in winter).
	Leader and lateral branches	Intense and/or repeated	Shape	Multiple forks and irreversible defects (bushy growth habit with no top). Stagnating growth or gradual desiccation of the branches, leading to the death of the tree (depending on species).
			Growth	In the growing season, loss of leaf mass (all tree species) and retarded aerial growth in young trees the following year (as with summer pruning) in proportion to the severity of the damage.
				In winter, loss of needle mass in evergreen conifers (the needles being the main nutrient storage sites). Less vigorous growth the following year due to the substantial loss of carbohydrates.
				Tree remains within the reach of animals for many years.
			Mortality	No natural regeneration due to almost total absence of seedlings (shoots and seedlings eaten).
				Mortality of young trees and natural seedlings (if all shoots are removed and in the event of severely reduced growth > 25 %, or if all needles and buds of evergreen conifers are consumed).
Browsing (Hares)	Leader	Once	Shape	Loss of apical dominance and loss of technical quality due to forking.
			Growth	Severely retarded height growth (if plant bitten through a few cm above the ground) or needles bitten off down to the base of the plant (feather duster look).
			Mortality	Sapling bitten through at the collar.
Rubbing (Deer)	Trunks of young trees	One side of the trunk	Shape	Loss of technological quality due to frequent development of branches below the rub.
			Growth	Severely retarded height growth.
				Formation of a callus around the wound (in some species, such as Douglas fir).
			Mortality	Possible springtime mortality of young trees and hand-planted seedlings due to gradual dieback of the tree portion above the exposed sapwood.
		All round the trunk		Dieback and snapping of the main trunk (and lateral branches).
Bark stripping (Deer)	Trunks of young trees	One side of the trunk	Growth	Retarded growth even if wound heals over (especially in the case of winter bark stripping).
				Loss of technological quality of the trunk through exposure to pathogenic rot fungi.
			Mortality	Outright mortality rare, but possible weakening of the mechanical resistance of the main trunk, greater susceptibility to wind and snow, ultimately causing the tree to snap.
Bark gnawing (Hares and rabbits)	Trunks (and low lateral branches) of young trees	One side of the trunk	Growth	Retarded height growth.
		Girdling	Mortality	Desiccation of the main trunk and death of the tree.

Criteria for identifying damage

Identifying the wild animal species responsible for damage to trees and shrubs is essential before attempting to establish any plantation of trees in forest or farmland, and it is the only effective way to choose a suitable method of protection. This analysis must be performed prior to planting: afterwards it will be too late. Learning to recognise the signs left by animals on natural vegetation helps to identify the culprit.

Diagnosing the risks

Once they are aware of the risks of damage to trees, the next logical step for forest managers is a preliminary diagnosis to assess the possible presence of wildlife in the vicinity of the future plantation, the size of the animal population, and in particular the pressure that it exerts on the environment.

Attributing the damage observed on a tree to a particular insect or fungus requires rather sophisticated diagnostic methods and, except in some very familiar cases, specialist advice is usually needed. With ruminants and hares, however, the diagnosis is generally much easier, even with only basic knowledge of their way of life and particular anatomical features.

The best way to draw up a list of potentially damaging species with any certainty is through field observations, and in particular by looking for and analysing the signs left by animals on the natural vegetation.

Examining the injuries inflicted on woody plants of young peripheral plantations and neighbouring mature stands provides valuable pointers, as the pattern of the injury varies according to the animal species. This examination requires careful observation of browsed shoots, rubbed or stripped stems and trunks, and gnawed bark.

There are usually plenty of specimens of damaged plants to hand, so it would be unusual not to find one exhibiting the most typical signs of damage.

To confirm the diagnosis with as much certainty as possible without actually having seen the animals, it is advisable to check with foresters and farmers in the vicinity of the proposed plantation site. Local hunters should also be able to provide information on which species are hunted, their level of abundance and population trends.

Browsed shoots

Aspect of injuries

The removal and consumption of buds, tender green young shoots and woody branches located within reach of animal teeth leaves wounds that differ in appearance, according to the species responsible.

Deer

Deer teeth do not make clean cuts, as they have no upper incisors.

5.1

5.2


6.1


6.2

5 - A horizontal (5.1), more or less chewed browsing injury (5.2) (here on *Cornus mas*) is the work of a roe deer.

6 - Damage to on a woody plant by a browsing rabbit is easily identified by the clean (6.1), oblique (6.2) cut.

7 - The damage to the maritime pine (7.1) is the work of a browsing roe deer. The spruce (7.2) has been browsed by a red deer. How can we know for sure?

8 - Browsing damage to red oak (8.1 and 8.2) and Norway maple (8.3) at a height of 120 cm to 145 cm.

In order to browse the most tender parts of plants to which they are attracted, such as buds, young shoots, leaves, and flowers, they pinch them between their very mobile upper lip (horny pad) and the incisors of their lower jaw, and then tear them off with a quick head jerk.

With this type of bite, the surface of the wound, which is almost perpendicular to the vertical axis of the shoot, looks torn or shredded, with no clean cut and no teeth marks **(Photo 5)**.

Deer can also chew tough branches of a larger diameter with their premolars. The wound will then have a chewed-up appearance. Sometimes the needles growing on conifer stems (pine, Douglas fir) are browsed off one by one down to the base of the plant.

Rabbits and hares

Unlike ruminants, rabbits and hares have large, specialised, extremely sharp incisors on both jaws.

As the animal grasps and cuts its food, the incisors rub against each other and chafe at an oblique angle (giving them a bevelled surface).


8.1


8.2


7.1


7.2


8.3

The resulting injury on a woody shoot is a very clean and distinct cut (like that of a razor), which is oblique in relation to the axis of the shoot **(Photo 6)**. This characteristic appearance allows careful observers to avoid any confusion with the marks left by deer.

Sometimes teeth marks can be seen on the cut with the aid of a magnifying glass. The slight difference in size between the incisors of a rabbit (2.5 mm) and a hare (3 mm) makes it difficult to identify which is responsible.

It is not uncommon to find cut, uneaten shoots lying at the base of a tree. This is probably because hares and rabbits bite off young branches to wear down their incisors, which grow continuously like human fingernails.

9.1

9.2

Which animal is responsible?

Simply observing the aspect of a browsing injury on a tree will not be enough to identify the species responsible within a given family (roe deer vs. red deer, rabbit vs. hare). The height of the wound also needs to be measured, as this provides valuable clues to the identity of the animal.

Trees are likely to be browsed until their leaders and lateral branches are high enough to be out of the reach of animals. Rabbits are known to reach branches as high as 60 cm, and hares as high as 70 cm. Roe deer, mouflon, Pyrenean and Alpine chamois and Reeves muntjacs can reach branches as high as 120 cm, whereas red deer, Sika deer, and fallow deer can reach to 180 cm **(Table 3)**.

These "maximum" accessible heights may be even greater under certain conditions. A steep slope, thick or hard snow cover (especially in the mountains), and wet snow weighing down lower lateral branches also place branches within easier reach of animal teeth.

Cases where animals bend or break stems to reach otherwise inaccessible but particularly attractive shoots are becoming more common. Such cases are undoubtedly linked to excessive densities in certain nutrient-poor territories and to lower planting densities of appetizing mineral-rich plants.

Roe deer often manage to bend young trees over by standing up and leaning against them, in order to reach buds as high as 1.5 m **(Photo 8)**. Nor is it uncommon for red deer to stand on their hind legs to reach appetising shoots nearly 2 m high. Sometimes they also snap trees several meters tall at a height of 1.5 m (which corresponds to about 1 cm in diameter) to reach the upper leaves, which are richer in nutrients and lower in fibre.

In areas where roe deer and red deer coexist, it is difficult to identify the species responsible when most of the trees are browsed at heights of 10 to 130 cm, in other words, when the damage is close to the ground **(Photo 7)**.

Only careful and patient examination of other signs of presence (tracks, faeces, hairs, etc.) in the vicinity of recently browsed tree will allow the damage to be attributed to one of the species when both are present.

Table 3 - Maximum height (cm) of wounds to trees caused by animals

	Rabbit	Hare	Roe deer	Red deer
Browsing	< 60	< 70	< 150	< 200
Rubbing	-	-	50 - 100	100 - 200
Bark stripping	-	-	-	30 - 200
Bark gnawing	< 50	< 60	-	-

When does the damage occur?

Deer

Browsing damage occurs all year round. Peak periods depend on tree species and can occur either during the dormant period (mainly conifers) or during the growing season (mainly leaves and green shoots of hardwoods).

Browsing in the winter (no sap flow) is more common in January-February when nutrient resources are scarce and other sources of food (brambles, dead leaves, mast, etc.) are covered by snow. Animals will browse woody shoots and terminal buds emerging from the snow cover, especially of conifers, which are generally a last resort in times of shortage **(Photo 9)**.

Browsing in the summer (during sap flow) occurs throughout the active growing season **(Photo 10)**, although the most intense damage occurs during spring budding. Breaking buds and unfolding leaves **(Photo 11)**, from which tender young shoots then emerge, are prime sources of fresh food **(Photo 12)** after a poor winter diet of woody conifer branches.

Hares and rabbits

Rabbits feed on buds all year round, whenever they are available. No tree species is spared.

Damage to young plantations is most common and most dramatic in the winter, when food is scarce and energy needs are high. During this period, the vulnerability of forest plantations to damage increases in proportion to the size of animal populations.

Browsing can rapidly lead to the near-total destruction of trees (40 to 90 %, depending on species) when rabbit densities are high (12 to 15 individuals per ha).

Vulnerability of different tree species

Deer

The vulnerability of a tree to browsing by roe deer and red deer varies according to season, tree species, the food available in the habitat, and silvicultural practice.

10.1

10.2

9 - These spruces were browsed by red deer during the winter. The main stem of the older tree (9.1) had fortunately grown past the maximum accessible height.

10 - A 120 cm mesh tree guard will not protect red oaks from browsing damage by red deer in the summer (during sap flow) (10.1). Few trees will remain unharmed (10.2).

11 - These young leaves and branches emerging on a plant damaged by browsing the previous year are a prime food source.

12 - The main stem of this red oak in full summer growth was browsed by a roe deer at a height above 120 cm.

11

12

By season

Deer eat conifer shoots and hardwood foliage and shoots all year round, but their preferences may vary with the seasons. Evergreen conifer species are browsed in the autumn and especially in winter when food is scarce. When it snows, terminal buds and shoots emerging from the snow cover are even more easily consumed and may then make up 45 % of the diet.

Hardwoods are generally consumed throughout the growing season, particularly in late spring, just after budbreak and when the shoots have not yet become woody. At this time of year, red deer prefer deciduous hardwoods and larches to evergreen conifers, whereas roe deer browse on a larger proportion of hardwoods than their abundance in the flora would suggest. They do not display this preference in the autumn and winter, indicating that roe deer prefer foliage to bare branches.

By species

Deer have a preference for silver fir, yew, oak, maple, ash, cherry, elm, locust, willow, and mountain ash. They are less attracted to pines (Scots, Corsican, maritime), spruce, Douglas fir, larch, beech, aspen, chestnut, walnut and white birch.

Some species such as silver birch, alder, and linden are rarely browsed and their consumption is considered an indication of excessive wildlife density.

By habitat

These preferences may vary considerably with localities. The level of consumption of a given tree species depends greatly on its habitat and in particular on:

- its abundance in the environment. When hardwood species are introduced into pure stands of conifers, the browsing problem may become acute;
- whether or not it is part of the animal's normal diet. This is particularly true for maritime pine, a dominant species in the Landes forest (SW France) where it is frequently browsed;
- the relative proportions of the main groups of food plants (hardwoods, conifers, grasses, herbaceous plants and shrubs such as raspberry, bramble, heather, blueberry), which determines the overall food supply for animals from that environment **(Photo 13)**. Browsing on species that are rarely or not normally sought out as food may be significant if the natural surrounding vegetation is not sufficiently abundant and attractive. Thus, plantations on bare ground (logged-over forest subsequently ploughed, cropfields, former meadows) are highly vulnerable, even if the tree species are not particularly attractive.

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Silvicultural practices

Silvicultural practices can also have an effect on the scale of damage.

Regeneration method

Nursery-grown trees of any given species are more frequently browsed during the first few years after planting than natural seedlings and stump shoots.

Many hypotheses have been put forward to explain this particular vulnerability of nursery-grown plants. Differences in nutritional quality could explain these discriminatory choices, implying that animals have the ability to choose trees according to the richness of the shoots in nutrients. According to another and perhaps more likely theory, this preference for artificially-grown trees could be explained by the fact that, because they were grown under better conditions, their shoots are longer, more accessible, and therefore more attractive.

Forest management techniques

If a forester promotes natural regeneration by creating temporary openings in the forest canopy to increase the amount of light, deer will have an abundance of plants from which to choose. In contrast, in stands where very little thinning is done, relatively few natural seedlings are produced and the impact of browsing becomes significant. Some permanently open environments with no forest cover, such as glades, turf, bogs, and some scree slopes are used as feeding zones and should be encouraged.

In artificial plantations, the quality of the installation and maintenance work determines how easily animals can reach the trees and is therefore of great importance.

In the first two to three years after planting on bare, deeply ploughed soil, the trees are easily accessible and extremely attractive to wild animals. There is also a close correlation between the vulnerability of the trees and the frequency of clearing to destroy competing herbaceous and semi-woody vegetation. During periods of food scarcity (end of winter), excessive or improper maintenance gives animals easy access to the young trees.

14

13 - Encouraging and maintaining brambles in fields is recommended to reduce the impact of roe deer on hardwoods and to promote natural regeneration of oak.

14 - Open corridors in stands of natural regrowth are trails for wildlife. It is important for the desired tree species to be well protected by companion species.

15 - If all of its shoots are removed, a plant has little (15.1) or no chance of survival (15.2).

Maintaining natural regeneration

Woody and semi-woody vegetation near the trees **(Photo 14)** can serve as natural protection from browsing, but can also make browsing of the trees more likely.

Less attractive plants of the same or larger size have a better protective effect (visual protection). On the other hand, the proximity of attractive plants (such as mountain ash, *Cornus spp., Rubus spp*. or field maple) can substantially increase the frequency of browsing.

Rabbits and hares

All tree species are browsed by rabbits and hares, which have a preference for hardwoods (beech, oak). However, they also browse some conifers (spruce, Douglas fir, Scots and Corsican pine, firs).

Although browsing damage to woody plants may be greater and more visible in the winter, no tree species is immune, regardless of the season.

Consequences of browsing

Tree mortality

In extreme cases, browsing can lead to the death of the tree. Although this generally applies only to natural shoots and seedlings, it can happen after planting, before the plants have had a chance to become established.

They have little chance of survival when all of their shoots are removed by intense or repeated browsing **(Photo 15)** and if their height growth is reduced by more than 25 %.

The mortality rate of trees diminishes greatly as they age, rapidly dropping to zero in older trees.

15.1

15.2

16

17

16 - When browsed by roe deer, a bush can grow replacement shoots from the collar.

17 - Upward growth of a lateral branch of a young European spindle-tree (*Euonymus europaeus*) browsed by a roe deer.

18 - Upward growth of lateral branches of a spruce after the terminal bud was eaten by a red deer.

Tree growth

Browsing on buds and branches with foliage during the growing season is a significant stress factor for both deciduous and evergreen species, and especially for evergreen conifers in the winter.

During the period of active photosynthesis (after spring budbreak and until leaf drop in the autumn), a large portion of the assimilates produced by leaves and needles is consumed by the plant for its own growth. Towards the end of the growing season, the plant's energy demand drops and nutrients migrate from the foliage to the storage areas of the tree, where they remain until the next budbreak.

If the leaf mass (and consequently the production of these nutrients) is reduced by browsing (as summer pruning would do), fewer reserves will have been stocked by the autumn and the tree will therefore grow less vigorously the following year, in proportion to the severity of the damage.

In winter, evergreen conifers are often more severely affected than deciduous species and larches. This is because the needles of these conifers are the main sites where nutrient reserves are stored. When browsing causes significant defoliation, it is also contributing to a considerable loss of these reserves, with a resulting decline in tree growth in the following year.

In contrast, winter consumption of the shoots of deciduous trees has almost no impact on the future development of the tree, since these species store their nutrient reserves in the woody portions of the young trunk and in their roots, which rarely browsed, if at all.

Lastly, a tree does not have time to recover when it is subjected to repeated browsing damage. Its reserves steadily decline, leading to considerable retardation in its height growth, so that it may remain within the reach of animals for years to come.

Tree shape

The most common and most severe impact is that which affects the terminal bud of the leader, as the latter is responsible for height growth and determines the future shape of the tree.

18

19.1

19.2

19 - When one (19.1) or more (19.2) sub-terminal shoots fork, corrective pruning will be required to ensure the future silvicultural quality of these black walnuts.

20 - Repeated browsing of terminal and lateral shoots over several years will gradually transform hardwood (20.1) and conifer (20.2 and 20.3) saplings into shrubs.

If the leader is destroyed, the tree loses its apical dominance and may react:

- by forming replacement shoots (from the buds that normally form on the remaining portion of the damaged shoot or from dormant lateral buds, **Photo 16**);
- by the upward growth of one **(Photo 17)** or more **(Photo 18)** upper lateral shoots.

This generally occurs over a single year and involves one or more upper branches.

If none of these new shoots becomes dominant, the tree will fork **(Photo 19)** or grow with several trunks **(Photo 20.1)**.

As a general rule, a single replacement stem will eventually become dominant, the others becoming ordinary branches. Nevertheless, this drastically alters the future silvicultural quality of the tree.

If these terminal and lateral shoots are repeatedly consumed over several years, the repetitive nature of the damage gives rise to serious morphological defects in the tree, which will become a shrub with multiple forks (bushy growth habit) and no real crown, easily mistaken for mere "underbrush" **(Photos 20.2 and 20.3)**.

20.1

20.2

20.3

21.1

21.2

Although spruces may survive for many years in this state, oaks decline rapidly and their branches wither one after another within a few years.

22

Rub wounds on stems and trunks

Aspect of injuries

Male deer rubbing stems and trunks with their antlers cause damage to young trees by tearing off various amounts of bark and sometimes even snapping the main trunk and/or lateral branches. The aspect of these behaviour-related injuries varies with the time of year in which they occur.

Rubs due to velvet scraping

The antlers of male roe deer and red deer (bucks and stags) are branched bony structures which they shed each year. New antlers start to grow immediately and very rapidly. They are covered at first with a soft skin known as "velvet", where there are a great many blood vessels. Once antler growth is complete, this skin is no longer needed and begins to peel off.

To speed up the process, males rub their antlers against thin and relatively flexible young tree trunks. Animals engaging in this behaviour may abrade the bark and the cambium until the sapwood is exposed, thus greatly compromising the future growth of the stems.

In this case, the bark is always damaged on just one side of the trunk **(Photo 21)**. As the deer do not eat the bark, it remains attached to the trunk by both ends in more or less shredded strips. Because certain areas of the velvet are sensitive, the animals are careful and this kind of rubbing is less forceful than rut rubs. Lateral branches or whorls are therefore rarely broken.

Rut rubs

Later in the year, when their antlers are fully developed, male deer may again damage trees and shrubs during the mating season (rut).

Rubbing is then much more forceful than when they are shedding their velvet, as the males engage in mock combats with young trees to release their aggression. During this period, bucks and stags mark their territories with visual and scent signals (glandular secretions) during the entire rutting period to warn others away.

Their state of arousal causes much more dramatic damage to trees than when they are shedding their velvet. Many branches, sometimes even the main trunk itself, may be snapped off **(Photo 22)**.

If sap is still flowing in the tree (during buck rut), the bark is lacerated and may be torn away from the entire circumference of the trunk. Trees that have thus been girdled die very quickly. Rub wounds are often comparable to bark stripping damage.

When sap flow ceases (at the time when the bellows of stags can be heard), the bark is not easily detached and rubbing no longer results in shredding. The bark is rubbed and worn down to the wood, and the edges of the wound are smooth **(Photo 23)**.

23

Deep marks in bark made by antler blows on trunks are sometimes easily visible. This type of injury, also known as "slashing" or "gouging", is often seen on large diameter trees **(Photo 24)**.

Which animal is responsible?

The animal causing the damage can be identified by the size of the tree and the height of the injury.

21 - Roebucks rubbing off their velvet will detach bark in strips, always on just one side of the trunk and only on trees less than 4 cm in diameter.

22 - The presence of broken branches on this locust is characteristic of a buck rub during rutting.

23 - Bark worn down to the wood and smooth wound edges are the result of a stag rub during the period when no sap is flowing (September - October).

24 - These deep marks in the bark of large diameter trees (cherry, 24.1; Douglas fir, 24.2) were made by antler blows from stags during the period when sap was not flowing.

25 - A buck rub on a locust tree: the rubbed area is 10 to 80 cm above the ground but can be as high as 100 cm.

24.1

24.2

25

Bucks shedding their velvet select young, flexible, pole-like trees (Ø < 4 cm, rarely more than 10 cm) **(Photo 21)** that are small enough to fit between the two antlers.

Stags also select trunks suited to the size of their antlers, usually 3 to 5 cm in diameter, but larger trunks may be attacked during the rut: trunks damaged by gouging **(Photo 24)** are generally 10 to 30 cm in diameter and sometimes more (up to 60 cm).

With roe deer, the rubbing zone is usually located between 10 and 80 cm from the ground **(Photo 25)**, but can be as high as 100 cm **(Table 3)**. With red deer, it is around 100 cm high, but can reach 200 cm **(Photo 26)**.

Abrasions due to roe bucks rubbing off their velvet usually less than 60 cm across, while those caused by stags are always more than 40 cm across.

When does the damage occur?

The damage occurs mainly during the velvet shedding or rutting periods, which vary with the species.

Whereas roebucks tolerate one another and form small groups in the winter, they suddenly turn solitary and aggressive towards one another in early spring. They scrape trees and shrubs with their front paws, rubbing in their scent to mark their territory.

Rubbing frequency varies a great deal during this period. It is most intense in the spring between March and May (velvet shedding), and again in the summer between July and August (rut rubs).

Stags rubs occur three times a year: shortly before they shed their antlers (February to March), and in particular from the velvet shedding stage (end of July to end of August) until they start to bellow (September-October).

Rut rub periods depend on the age of the stags and may vary locally. The oldest stags tend to be the first to go into rut and they mark their territories earlier.

Vulnerability of different tree species

Male deer (stags and bucks) vigorously rub saplings and young trees, sometimes even in the pole stage. They prefer aromatic species that are rich in essential oils and aromatic resins, such as Douglas firs, giant firs, pines, larches and yew, but also cherry, juniper, elderberry, and buckthorn.

Silver firs and spruces are occasionally damaged, but browsing is definitely a greater threat to these species than rubbing.

In young plantations, certain trees may be broken and others rendered unfit for commercial forestry. Animals choose trees with supple trunks and smooth bark, with lower branches set relatively high.

Large, widely-spaced hardwood saplings with few lateral branches and softwoods like poplar and willow are very vulnerable to rubbing. Species that are not site-adapted, locally rare (maple, ash, mountain ash) or present in stands in small numbers are also vulnerable. Beech and other oaks are rarely affected.

26

Consequences of rub injuries

Bark injuries caused by rubbing can interfere with growth or even cause the death of the tree if they are severe or if the stem or trunk has been girdled.

When the sap is rising, forceful rubbing easily tears away the surface tissue (bark and cambium), which soon falls away once it is separated from the sapwood **(Photo 27)**.

If it is not snapped and if the trunk is not girdled, the young tree may survive, but its growth will be severely retarded in subsequent growing seasons.

Some species **(Photo 28)** may react by forming a callus around the wound, but in most cases, the process observed is fairly rapid desiccation of the entire portion of the tree above the exposed sapwood.

This is followed by rapid growth of undamaged lateral branches below the scar and sometimes the development of one or more shoots, compromising the silvicultural future of the tree.

When the trunk snaps as a result of slashing during rut, the tree reacts in a similar way to that observed after browsing of the leader, with the terminals growing upwards or the formation of replacement shoots.

27

Stripped stems and trunks

Aspect of injuries and period of occurrence

Bark stripping can be very serious locally and is perhaps the most dramatic of all types of animal damage. The consumption of whole bark pieces by red deer (by tearing or gnawing) causes injuries of two kinds, which vary in aspect according to the physiological condition of the tree when the damage occurred.

Bark stripping during sap flow

In the summer (during sap flow), bark detaches easily from the underlying cambium. The animal is able to grasp the bark by pinching it between its lower incisors and the bony pad of its upper jaw, and then tear off a long, upwardly tapering strip ending in a point **(Photo 29)** or at the insertion of a lateral branch. No teeth marks are visible. The bark is eaten, leaving no hanging strips.

In contrast to the smooth, gradually worn edges of rub wounds, the edges of bark stripping wounds are sharp. Several strips may be torn off side by side, but rarely from more than 50 % of the circumference of the trunk. A callus forms, but the scar frequently remains until the death of the tree.

Bark stripping when no sap is flowing

In the winter (no sap flow), the bark adheres tightly to the wood and the animal cannot tear it off in strips. It will therefore nibble at the bark with its incisors, removing it little by little. This injury, which is easy to recognise **(Photo 30)**, rarely reaches the same proportions as summer bark stripping.

Teeth marks are easily visible, side by side and separated by the remaining pieces of cambium. Often the marks of only one of the two lower incisors are apparent, as the animal gnaws the bark by turning its head slightly to one side or the other.

26 - A black alder damaged by a stag rubbing off velvet: the rubbed area is around 100 cm above the ground, but can reach 200 cm.

27 - Wildlife pressure on commercial hardwood plantations is increasing. This Norway maple has been rubbed by a roe buck in rut despite the mesh tree guard.

28 - Unlike the gouge on the mature cherry tree (28.2), the wound on the cherry sapling (28.1) is not healing easily.

28.1

28.2


29


30

Which animal is responsible?

Red deer are responsible for this type of damage. Roe deer rarely strip bark from trees, and only during periods of extreme and prolonged food scarcity in poor biotopes with high animal densities.

Damage occurs between 70 and 120 cm above the ground, but can extend from 30 to 200 cm **(Table 3)**. The teeth marks on the cambium are 8 to 9 mm in width.

Vulnerability of different tree species

The differences in vulnerability among tree species are fairly distinct, but can vary in different stands, with bark stripping occurring on the most prevalent species. Their vulnerability is proportional to the fragility of their bark and the time required for suberisation.

Red deer only feed on thin bark. Spruce, ash, chestnut **(Photo 31)** and mountain ash are frequently stripped. Other species commonly affected include Douglas fir, Scots pine, beech and poplar. Some species such as fir, oak, alder and birch are rarely affected.

Trees may be stripped as soon as their trunks become accessible when the lowest lateral branches die back (natural pruning). The damage often increases in intensity soon after artificial pruning prior to the first thinning.

Bark stripping begins when trees reach a diameter at breast height (DBH) of 1 to 2 cm, but damage is most frequent in saplings of 10 to 15 cm, especially spruce, Douglas fir and beech. Trees are no longer vulnerable to bark stripping when the bark becomes too thick and difficult to remove.

Species that take a long time to develop thick bark, such as beech (10 to 30 years) and spruce (10 to 45 years), remain vulnerable for longer than species in which the bark quickly becomes hard and rough through early suberisation, such as Douglas fir (6 to 20 years) and especially pines (4 to 10 years).

Consequences of bark stripping

Bark stripping rarely occurs around the entire circumference and almost never leads directly to the death of the tree. It may survive (especially in the case of winter bark stripping) and continue to grow slowly while gradually recovering from the injury.

Its healing capacity will depend on many factors, including the size of the wound (large wounds heal more slowly), the age of the tree (healing takes more time in old trees), the season in which the injury occurred, the species (some species heal faster than others), and the spectrum of microorganisms and rot fungi colonizing the wound.

Even if a callus forms, the scar generally remains visible until the death of the tree and remains exposed to fungal rot that deteriorates the timber of the butt log, making it totally unfit for commercial use. Trees with low resistance to mechanical stress in the vicinity of the damaged zone may then snap under wind or snow pressure **(Photo 32)**.

Healing slows in proportion to the size of the wound and the age of the injured trunk. Economic losses will depend on the species and volume of the rotted zone that needs to be cut out. As a general rule, economic losses are not too great for rapidly healing species such as Douglas fir, but are significant in spruces or Scots pine, which do not heal well.

Gnawed bark

Aspect of injuries

Due to the nature of their teeth, rabbits and hares, unlike ruminants, cannot tear off strips of bark, even during the growing season (sap flow). They have extremely sharp incisors on both jaws, requiring them to nibble at the bark in order to feed **(Photo 33)**.

As a general rule, hares and rabbits damage trees less than 5 to 6 cm in diameter, sometimes feeding on low-growing

31

lateral branches. The injury is generally at a very oblique angle to the axis of the shoot, and the exposed portion of the wood is surrounded by an area of characteristically bevelled bark. The marks of both incisors are often visible on each bite. The trunk may be completely girdled.

32

Which animal is responsible?

The species (rabbit or hare) responsible can be identified by the width of the teeth marks on the wood and the height of the damage above the ground.

The total width of both incisors is about 5 cm in rabbits and 6 mm in hares. For the record, it varies from 1.5 to 2.5 mm in small rodents (mainly voles) **(Photo 34)**.

Rabbits gnaw from the collar to a height of 45-50 cm **(Table 3, p.12)**. Hares rarely gnaw higher than 70 cm. Small rodent wounds are found at the collar of the tree, no higher than 15 cm above the ground.

The presence of droppings (which are larger and more scattered in hares than in rabbits) also helps to identify the animal responsible.

When does the damage occur?

Bark gnawing is feeding-related damage and closely correlated with food scarcity and with the animal's need to wear down its incisors.

As with browsing, it mainly occurs during the winter, when food is scarce and the main food source, herbaceous plants, is insufficient in quantity and quality.

Vulnerability of different tree species

Hares and rabbits prefer hardwoods. The most vulnerable species are beech and oak, but damage is often found on cherry, ash, poplar, aspen and willow.

Conifers are less affected: those most frequently damaged are Douglas fir and pines (Corsican and Scots).

29 - Summer bark stripping on a Douglas fir: bark torn off in tapering strips, wound edges sharp and not worn smooth by rubbing.

30 - Bark stripping damage on ash during the period when no sap is flowing.

31 - The teeth marks of red deer are clearly visible on the exposed cambium of this chestnut tree.

32 - Snapped stem of a spruce subsequent to rotting induced by bark stripping during sap flow.

33 - Maple bark gnawedby a rabbit.

34 - Underground bark gnawing is the work of small rodents.

33

34

Choosing the right tree guard

Although it is often necessary to protect trees and shrubs from wildlife damage, unsuitable and consequently ineffective strategies are observed far too often in the field. The wide diversity of tree guards currently on the market requires forestry professionals to find out what is available and identify the products that best meet their needs. Installing tree protection is usually quite expensive and the technical specifications of the different products are quite complex for non-specialists. Foresters or farmers need to be well acquainted with the different types in order to use them properly and make the right choice for protecting trees from the types of damage observed in the local situation.

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How and when to use tree guards?

Mesh tree guards and individual fences are made of fine or wide-meshed plastic or metal and are designed to provide total or partial "mechanical" protection of individual trees.

Unlike "chemical" repellants[2] **(Photo 35)**, "mechanical" protection is designed to physically prevent animals from causing damage, by keeping them at a distance from the trunk of the tree so that they cannot rub against it or browse the branches and terminal buds.

Whereas "overall" site protection (wire mesh or electric fences) is designed to exclude animals altogether from a newly planted area **(Photo 36)**, "individual" protection restricts access to the trees **(Photo 37)** but otherwise allows animals to move around the site and forage among the individually protected trees **(Table 4)**. This type of protection must be placed closely around the tree and must have certain mechanical resistance characteristics. It is suited to both artificial plantings and naturally regenerating stands.

Tree guards come in two categories, according to whether they protect:

- the whole plant: "total" tree protection is when the tree guard protects the whole tree (stem and crown) from every possible type of damage from a given animal species. Examples include wide-meshed (≥ 5 mm) plastic tree guards to keep rabbits from browsing and gnawing on bark but also simple, mixed-mesh or reinforced fine-meshed (≤ 4 mm) tree guards that prevent rubbing and browsing by roe deer **(Photo 37)**;
- part of the plant: when the aim is to prevent only one type of damage (rubbing or bark stripping), the protection is referred to as "partial". The type of damage to be prevented needs to be known, since a mesh tree guard is placed on the particular part of the plant likely to be damaged. For example, fine-meshed tree guards are

(2) Chemical repellants are painted or sprayed onto plants or trees. They repel animals by their taste or smell, which is formulated according to the animal to be discouraged and to the type of damage to be prevented.

37

38

35 - Applying a repellant (animal and tar extracts) to prevent stag rubs on Douglas fir.

36 - A wire mesh fence can be used to protect extensive naturally regenerating and artificial stands from large animals. Shown here is a fence around a plantation of Christmas trees (Nordmann firs) to prevent red deer damage.

37 - Tree guards (ht 120 cm) protecting against roe deer damage to Norway maples. Foreground: heavyweight (± 420g/m²) reinforced fine-meshed tree guard (Ø 15 cm); background: climate-regulating tree guard (Ø 15 cm).

38 - Heavyweight (± 410 g/m²) mesh tree guard in expandable diamond-shaped mesh (ht 180 cm, extended width 50 cm) on a Douglas fir to prevent rubbing and bark stripping by red deer.

placed around young broadleaved and poplar stems to protect them from buck rubs. Tree guards in expandable diamond-shaped mesh can be wrapped around the trunks of fragrant conifers to protect them from bark stripping by red deer **(Photo 38)**.

Table 4 - Advantages and disadvantages of individual and overall mechanical protection

PROTECTION	INDIVIDUAL TREES	WHOLE SITE (FENCING)
Advantages	▪ Competitively priced for low to medium density naturally regenerating woodlands and artificial plantations **(Photo 39)**. ▪ Allows animals (and hunters) to circulate freely without restricting foraging possibilities in the site. ▪ Makes young trees easily identifiable during mechanical or manual clearing operations (particularly in low-density plantings). ▪ Fast and easy to install, much less expensive than fencing (except for high planting densities or large areas).	▪ Competitively priced for extensive high-density naturally regenerating woodlands and artificial plantations. ▪ Provides lasting physical protection against all types of damage without endangering the trees. ▪ More effective protection against red deer than individual tree guards. ▪ Cost per plant protected diminishes with increasing planting density or area. ▪ Effective protection of companion trees in mixed hardwood plantations.
Disavantages	▪ Cost prohibitive for high-density plantings over large areas. ▪ Never 100 % effective with high animal densities **(Photo 40)**, except at prohibitive cost. ▪ Weather resistance sometimes poor if stakes are of low quality. ▪ Some tree guards can cause tree deformation or become embedded in the trunk if not removed in time **(Photo 41)**. ▪ Regular checking involves costs that vary depending on planting density. ▪ Visual and environmental pollution and risk of impacts on the plants if not removed in time **(Photo 42)**.	▪ Higher cost for low-density plantings over small areas. ▪ Installation is time-consuming and difficult for foresters working at hourly rates. ▪ Animals lose access to part of their habitat and can cause more damage to unprotected plant populations. ▪ Fences prevent circulation between neighbouring properties and are sometimes resented by neighbours. ▪ Can be ineffective on uneven land (ditches, natural slopes). ▪ Fences require constant checking to prevent animals from being trapped in the enclosure (turning it into a game enclosure).

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Quality criteria

Making the right choice

The choice of a mesh tree guard should not be dictated solely by the price. Ignoring their actual effectiveness against animal damage never makes good economic sense. Tree guards should be chosen according to the tree species to be protected, the initial height and growth rate of the saplings, and also the animals concerned, their density and the potential risks.

Resistances to deterioration over time and to tearing, piercing or gnawing are key criteria for the effectiveness of mesh tree guards. Their resistance depends on weight, composition, the moulding extrusion method and the number of plastic filaments (or strands) **(Photo 43)**.

Height and diameter

The effectiveness of a mesh tree guard depends on its capacity to protect young woody plants, saplings or mature trees during their entire period of vulnerability. The types of potential damage, the animals responsible - which should be identified beforehand - and their density, should all be taken into account when making the choice.

The minimum height of a tree guard must always be greater than the critical height of possible injuries inflicted on trees by an animal **(Table 3, p.12)**. The standard heights of tree guards currently on the market are 50 cm for rabbits, 60 cm for hares, 120 cm for roe deer, and 180 cm for red deer.

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43.1

43.2

39 - Semi-rigid (ht 120 cm, Ø 14 cm), medium weight (330 g/m²) fine-mesh tree guards were chosen to protect this low-density (833 plants/ha; 4 x 3 m) mixed planting of red oak and Norway maple.

40 - The flexible main shoot of this young red oak was rubbed by a roe deer during the rutting season (mid-July to mid-August) after it had pulled off the standard-weight (± 200 g/m²) flexible mesh guard (ht 120 cm, Ø 14 cm).

41 - If not removed in time, metal stakes can quickly become embedded in the lower trunk of fast-growing tree species such as locust trees.

42 - This mesh tree guard has deteriorated and is no longer protecting the tree; it must be disposed of to avoid environmental pollution.

44 - In this experimental plantation, a rigid, medium-weight (330 g/m²), 3-stranded reinforced mesh tree guard (43.1) withstood attacks by roe deer, but the lighter (270 g/m²), 2-stranded guard (43.2) was torn and the young tree was browsed and rubbed.

In areas where food is scarce and deer populations very dense, the attractiveness of newly planted trees often compels foresters to use higher, heavier, more rigid and necessarily more expensive tree guards.

These should be 150 cm high for roe deer and 200 cm high for red deer, and supported by reinforced wooden stakes, since deer can bend young trees or rear up on their hind legs to reach appetising shoots.

The diameter of tree guards varies from 10 cm to 33 cm and will depend on the type of tree to be protected:

- 10 cm to 15 cm for poplar;
- 14 cm to 15 cm for hardwoods with strong apical dominance (e.g., cherry, ash, maple, red oak);
- 20 cm to 25 cm for hardwoods with strong lateral development and weak apical dominance (oak, beech, walnut, service tree), and also for very fast-growing softwoods with flexible branches (Douglas fir, larch);
- a diameter of 30 cm to 33 cm is acceptable for conifers.

Durability of synthetic plastics

Durability is a key parameter. During their useful life, tree guards are exposed to bad weather and to sunlight. Foresters must be aware of the type and quality of the constituent materials, which determine how quickly the tree guard will deteriorate and how long it will provide effective protection against animals.

Six years are considered as a minimum in forests (at least 10 years in agroforestry), but

Polyolefins

Mesh tree guards are made of one or more synthetic organic polymers combined with stabilisers, plasticisers and dyes that together make up the plastic material. These polymers are produced by chemical reactions, like the naphtha and diesel produced from petroleum distillation.

They belong to the family of polyolefin chemicals and are mostly derived from the polymerization of ethylene (polyethylene PE) or propylene (polypropylene PP) monomers. Identifying them is easy because they give off a thin white smoke and a smell of candlewax when they burn, and will float on water.

Their main technological characteristics explain their success: they are lightweight and resistant to corrosion, chemicals (pesticides, fertilizers) and biological agents (bacteria, fungi).

They are described as "thermoplastic", meaning that they are softened by heat and become malleable, so that they can be shaped and processed into a wide variety of mesh tree guards.

this will vary with tree species, their growth rates and the presence, or not, of companion plants, which can be important as a means of indirect protection.

Three different polymers (polyolefins) may be used for forestry supplies: polyvinyl chloride (PVC), polypropylene (PP) and polyethylene (PE). They differ in their chemical structure, degradability and resistance to climatic conditions:

- although cheap, PVC should be avoided. It has a rather short useful life because it gradually hardens as it loses plasticity. It contains chlorine and is therefore an environmental hazard;
- although PP is sturdier and more rigid than PE, it is more sensitive to oxidation, becoming fragile and brittle with age;
- PE is the polymer with the best performance because its particular molecular structure guarantees the elasticity and tensile strength of the final product **(Tip 1)**.

Durability of biodegradable plastics

New "biodegradable" tree guards against damage by hares, rabbits and roe deer have recently become available on the European market. The material is based on corn starch, potato starch and carbon, but its chemical formulation and bio-assimilation by soil microorganisms are unknown.

These products do not have conformity labels providing information for buyers.

50-cm biodegradable tree guards will rapidly decompose to a height of 10 cm to 15 cm from the ground when they are in contact with the surrounding vegetation. This allows rabbits easy access to the stem of the "protected" plant **(Photo 45)**. 120-cm tree guards quickly lose their rigidity and mechanical resistance. They tear at the folds and gradually sag down to the base of the young tree during the 2nd growing season **(Photo 46)**.

Because their useful life is currently less than 2 years (with a guarantee of 18 months max.), biodegradable tree guards are not well suited to forestry. Furthermore, as long-term storage is impossible, they are only available on order.

Tip 1 - Choose between PP and PE

Do not simply settle for a "polyolefin" tree guard, but have the primary material specified in the contract: the sale price of PP is lower than that of PE. Given the absence of quality standards for forestry materials and the rising price of petroleum from which these hydrocarbon polymers are produced, there is a risk of PP being added to PE, to the detriment of product durability and performance.

For total tree protection, preference should be given to mesh guards made of high-density polyethylene (HDPE). HDPE products are more rigid and less elastic; they eventually tear but can leave marks on thin bark **(Photo 44)**. For partial protection, expandable mesh guards made of low-density polyethylene (LDPE) are an option: the mesh stretches without injuring the tree and eventually breaks as the tree grows in girth.

PE should contain added stabilisers to protect against decomposition by heat, oxidation and sunlight. Plastics for forestry in particular must contain ultraviolet (UV) radiation absorbers, which considerably improve the resistance of the finished product to photodecomposition and therefore their durability.

Tip 2 - What is a "biodegradable" material?

A material is biodegradable if it is broken down by microorganisms (microflora and microfauna) that use the material as a nutrient. This is called bio-assimilation, and results in the production of water, carbon dioxide and/or methane, and sometimes other by-products that are non-toxic for the environment.

Interest in the use of biodegradable materials has prompted some industrial manufacturers to offer pseudo-biodegradable products. It is important to be careful, because these materials, made from blends of polyethylene and starch or oxidant, are in fact "photofragmentable" rather than biodegradable; in other words, they are broken down over time (by exposure to light, heat or extreme cold) into pieces that are smaller and smaller but are not bio-assimilable.

This practice is misleading for users, because although - in the best of cases - these fragments are invisible, the polymer will remain in the soil.

Moreover, there is no knowledge at present about how these pieces of plastic and their additives will evolve, or about their impact on the environment through long-term accumulation.

Weight

When choosing a plastic mesh tree guard, the factors to consider are the mesh size, the number and thickness of strands and the possible presence of reinforcing material, all of which determine the weight and especially the resistance of the product to animal damage.

Forestry supply catalogues currently give weights in grams per linear meter (lm). However, this is not a reliable indication when choosing between two products of equal height but different brands and/or diameters. Weight in grams per m^2 is the only realistic criterion for reliable comparisons between different types of protection **(Tip 3)**.

Mesh tree guards come in five weight categories.

Lightweight ($\leq$ 150 g/m^2)

These are mainly wide-meshed ($\geq$ 8 mm) lightweight ($\pm$ 90 - 100 g/m^2) tree guards used to deter rabbits, hares, and small


44.1


44.2

44 - High-density PE-based medium-weight (± 250 - 350 g/m²) tree guards with mixed mesh sizes will tear as the tree grows in girth (44.1) but can leave marks on the bark (44.2).

45 - Bark gnawing damage by rabbits on a tree protected by a 50 cm biodegradable tree guard (ht 60 cm, Ø 17 cm), which has partly decomposed (due to contact with weeds) after 2 years on the site.

46 - Browsing damage to a red oak inside a biodegradable tree guard (ht 120 cm, Ø 14 cm) that was torn apart by roe deer.

rodents from damaging small trees, shrubs or vines **(Photo 47)** in forests, parklands, orchards and vineyards.

These tree guards are above all lightweight and economical. The 40-cm models are not recommended because they are not high enough to protect against rabbits.

Heavier (150 g/m²) deterrent tree guards with a finer mesh (4 mm) to contain the terminal bud and lateral branches are also available at competitive prices.

Standard (± 200 - 250 g/m²)

This range comprises fine-meshed (2-4 mm) tree guards **(Photo 48)** that protect small woody plants against damage by rabbits, hares and roe deer. The fine mesh stops the main shoots from pushing out sideways and becoming deformed, and especially from being browsed by animals.

Tip 3 - Work out the weight in grams per m²

Use the following formula to calculate the weight of a mesh tree guard in grams per square meter (W in g/m²):

$W = g/(\pi.\ \varnothing/100)$,

where :

- g : grams per linear meter (g/lm) ;
- π : mathematical constant equal to 3.1416 ;
- Ø : diameter (cm) of the mesh tree guard.


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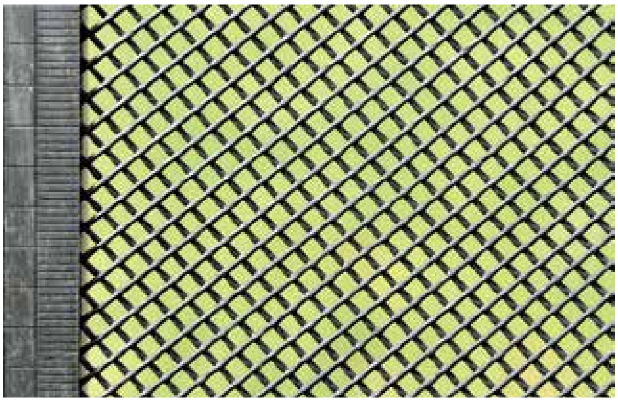

48

For protection against roe deer, preference should be given to heavier weights that provide more rigidity, better protection from hare and rabbit damage and better resistance to wind (they will not twist around the trunk) and snow (less risk of collapse).

In areas where hare damage is a potential problem (hares will stand on their hind legs to try to pull the tree guards down, thus crushing them), we recommend a heavier (medium-weight) mesh with good vertical rigidity (thanks to longitudinal reinforcement canes in the 4 folds) and better tear resistance (horizontal reinforcement rings every 10 cm).

If herbicides are used, tree guards with a solid bottom portion (where the top mesh portion represents 25 % to 50 % of the total height) can be useful because they will protect the tree from herbicide drift. This type of product (40 cm to 60 cm in height) with four pre-formed folds (easy to shape into a square) and longitudinal reinforcements (good rigidity) is mainly used in vineyards.

Medium weight (± 250 - 350 g/m^2)

Mixed-mesh tree guards are designed to protect trees from roe deer damage but are too small to deter red deer.

These are made of double-stranded mesh **(Photo 49)**. The wider mesh sizes (thickest strands) provide good vertical rigidity (27 x 27 cm). The finer mesh sizes (fine strands) ensure better protection from browsing by keeping the buds of the leader and lateral branches inside the tree guard (3 x 3 mm).

The medium-weight range also includes rigid, wide-diameter (30 cm to 33 cm) tree guards with a wide (20 x 20 mm) diamond-shaped mesh **(Photo 54)**. These have very strong, thick (2 mm) strands and are recommended mainly for protecting conifers from deer.

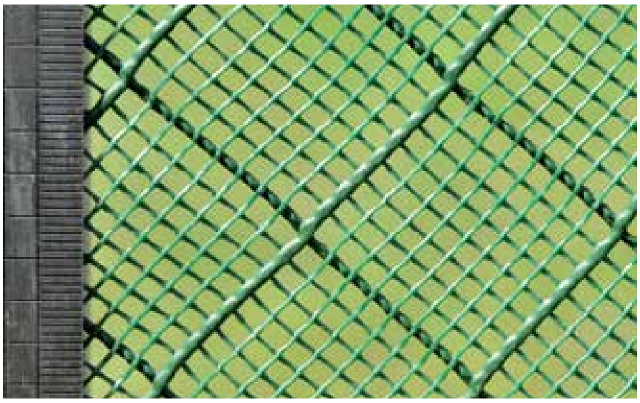
For red deer, the mesh must be fastened to two strong, large-diameter (Ø 6-8 cm) chestnut, locustwood or oak stakes.

Heavyweight (± 400 - 450 g/m^2)

Reinforced double-mesh tree guards are recommended for high deer densities and are increasingly used **(Photo 50)**.

They have a mixed mesh characterised by thicker horizontal and vertical strands providing greater tear resistance. Because they are both rigid and durable, routine inspections are only necessary once the mesh comes into close contact with the lower part of the trunk.

Four pre-formed folds make the mesh guard easy to open for placing on the tree without injuring the tip, and help to maintain an oval cross-section to ensure the tree can grow out of the top.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Ultra-heavyweight (> 500 g/m²)

To meet the specific requirements for protecting hardwoods in agroforestry plantations from roe deer damage, a new type of tree guard with innovative features is now being marketed **(Photo 51)**.

These have large diameter (2 mm) strands for better tear resistance and a small mesh size (5 x 5 mm) to stop terminal buds from pushing out sideways.

Their weight (± 700 g/m²) makes them very rigid, extremely durable and highly resistant to tearing.

The 150-cm height prevents roe deer from reaching the main stem and the 20 cm diameter reduces the risks of the mesh rubbing against thin bark. Ideally, this type of guard is fastened to one or two sturdy pointed chestnut stakes (ht 180 cm; Ø 4-6 cm).

47 - Close-up of a lightweight, wide-meshed (8 x 8 mm) tree guard used to deter animals from browsing.

48 - Close-up of a standard fine-meshed (3 x 3 mm) tree guard.

49 - Close-up of a medium-weight double-meshed tree guard (27 x 27 mm/3 x 3 mm).

50 - Close-up of a heavyweight, reinforced double-mesh tree guard (25 x 25 mm/ 2.5 x 2.5 mm).

51 - An agroforestry tree guard (ht 150 cm, Ø 20 cm) is an ultra-heavyweight (> 700 g/m²), wide-meshed (5 x 5 mm) protective guard designed to protect trees planted at very low densities.

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Types of mesh tree guards

Total tree protection

Lightweight wide-meshed (≥ 5 mm) tree guard

Lightweight mesh tree guards (± 90 to 100 g/m²) can be used to deter browsing animals. They are made from black, blue, green or dark brown plastic mesh (5 to 10 mm, in a square or diamond shape). The mesh is cut to the desired length to form individual tree guards (Ø 14 to 30 cm). They can be purchased in 100-m rolls, which are 2 to 2.5 % cheaper than individual tree guards.

These are recommended for reducing rabbit, hare and small rodent damage to young trees in forests, orchards, parklands or vineyards. With high rabbit or hare densities, a heavier weight (≥ 200 g/m²) and a finer mesh are preferable.

The mesh guards are shipped flat in packages of 100 and therefore easy to transport. They are quickly installed by slipping them down the plant from the top and inserting two bamboo stakes (Ø large end 6-8 mm).

In windy regions, it is advisable to attach the mesh tree guard to thicker bamboo stakes (Ø large end 8-10 mm, using with metal "pig-nose" clips), to two metal stakes **(Photo 52)** or to a single wooden stake.

Ultra-wide meshed (≥ 15 mm) tree guard

Ultra-wide black plastic mesh **(Photo 53)** of medium weight (± 300 g/m²) with a simple diamond shape (20 x 20 mm) is used to make tree guards 30-33 cm in diameter.

These are highly resistant to stretching and tearing. They will last for considerably more than 10 years with an anti-UV treatment.

They are not recommended for total protection of small broadleaved trees, even those with strong apical dominance (e.g., cherry, maple or ash). Since their shoots frequently grow laterally through the mesh, the risk of malformation of the main stem and browsing of the terminal bud is quite high **(Photo 54, Photo 55)**.

Because of the mesh size, bucks and stags can also lift or even tear off this type of tree guard with their antlers.

These tree guards are primarily designed to protect conifers from deer damage. They can also be used to prevent risks of browsing, rubbing and bark stripping by red deer **(Photo 58)** in low-density plantations of the most sensitive species, tall hardwood saplings (stem height > 1.50 m) or fruit trees with the lower branches removed.

These mesh tree guards are bulky and come in packs of 25. They are placed by slipping them down the tree and stapling them to two pointed chestnut (C 11/13 mm) or locustwood (S 22 x 22 mm) stakes (L 150 cm) for protection from roe deer. For red deer, we recommend using two round posts of natural chestnut (Ø 6-8 cm) or machine-rounded treated pine (Ø 5-6 cm).

Ultra-wide metal mesh tree guard

Metal mesh tree guards are made from steel wire, galvanised or not. Two types of mesh are used: chicken wire for rabbits, hares, and roe deer, and expensive heavyweight mesh for "individual fences" to protect trees from red deer.

"Chicken wire", so called because it is commonly used to make chicken coops, aviaries and rabbit hutches, is a type of netting made of 1 mm steel wire woven into a wide 13 to 50 mm hexagonal mesh **(Photo 56)**. It is sold in rolls and easily cut by hand through the twists of the strands into rectangu-

52 - Wide-meshed (8 x 8 mm) lightweight (187 g/m²) tree guards protecting shrubs from hares (ht 60 cm, Ø 17 cm).

53 - Ultra-wide mesh (20 x 20 mm) medium-weight (290 g/m²) tree guard protecting a red oak from roe deer damage (ht 120 cm, Ø 33 cm).


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lar sheets (60 cm or 120 cm x 80 cm). When the user can choose the final diameter of the tree guard, it is usually installed by fastening it to form a 25-cm diameter tube around 2 bamboo stakes (ht 90 cm and Ø 6-8 mm) with 3 wire ties, or to one or two wooden stakes (ht 150 cm and C 9-11 cm) by nailing the edges together with 4 fence staples.

Although widely used in the past, this type of netting is strongly discouraged nowadays for several reasons:

- malformation of the tree when the leader grows laterally through the mesh (so that animals can reach it with their teeth) and high risk of bucks tearing it off with their antlers during the rutting season (classic disadvantage of wide-mesh tree guards);
- it tends to be crushed without regaining its original shape when pawed by a roe deer (as they try to pull it off), which makes it useless;
- it has to be removed eventually (which means dismantling the worn netting and taking it to a recycling centre): removal is often a difficult, time-consuming **(Photo 56)**, and therefore expensive operation;
- possible rubbing injuries to the main stem of trees with thin bark; if not removed, the netting lasts for a very long time and the metal will become embedded in the lower trunk, thus compromising the quality of the butt log;
- the market price is much higher than for a plastic ultra-wide mesh (≥ 15 mm) tree guard.

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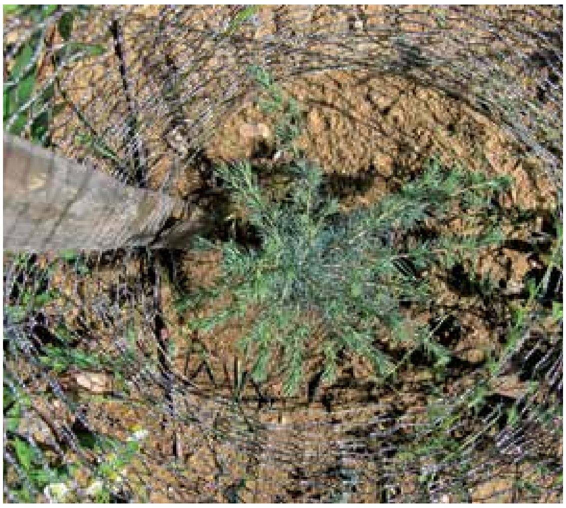
54 - The terminal buds of the young red oak (54.1) and Norway maple (54.2) grew through the mesh of their tree guards and were browsed by roe deer; another bud (54.3) will soon meet the same fate.

55 - Browsing of a lateral branch will not compromise the future silvicultural value of a tree as long as the main stem is unharmed.

56 - The branch whorls of an Atlas cedar have gradually grown through the mesh of its chicken-wire tree guard. The metal wire will have to be removed so that it does not become embedded in the lower trunk of the tree, a time-consuming and tedious operation.



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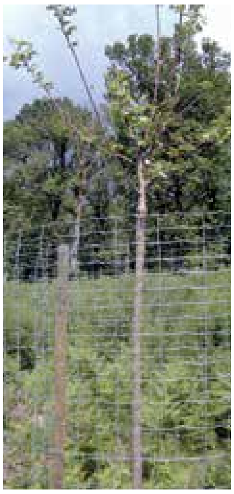

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57 - Different types of individual wire mesh protection (ht 200 cm) against red deer damage: an individual fence (Ursus® type) with a finely-meshed upper section is fastened to one oak fence-post around a larch (57.1), to two industrial treated pine posts (L 250 cm, Ø 6/8 cm) around a broadleaved tree (57.2) or to four oak posts (L 250 cm, C 30-40 cm) around a horse chestnut (57.3).

"Individual metal wire mesh fences" can be used to protect young woody plants individually from red deer in forests, but also in orchards, woodlots, forestry and agroforestry plantations of commercial hardwoods, ornamental trees, (future) tree-lined avenues, etc.

Tip 4 - Choosing the right tree guard against red deer damage

There is no 100 % effective method for total tree protection at a reasonable price when red deer pressure is very severe. Commercial hardwoods are routinely damaged by animals browsing or snapping branches that grow out of mesh tree guards up to 180 cm above the ground.

Individual metal wire mesh fences **(Photo 57)** ensure effective total protection, but the cost is prohibitive : €5.5 to €5.8 (excluding VAT) for Cyclone fencing (ht 205 cm, Ø 100 cm) plus € 3.1 to €3.4 excluding VAT per fence-post (L 250 cm, Ø 8-10 cm). Not including cutting and installation time, an individual wire mesh fence with two posts **(Photo 58)** will cost €11.7 to €12.6 on average, excluding VAT; €17.9 to € 19.4 with four wooden posts.

Plastic tree guards (ht 180 cm, Ø 30-33 cm), with an ultra-wide 20 x 20 mm diamond-shaped mesh (320 to 340 g m²) and two posts are a less expensive alternative at €2.5 to €2.9 (excluding VAT) for each mesh tree guard, plus €2.4 to €2.6 (excluding VAT) per industrial treated pine post (L 250 cm, Ø 5-6 cm), i.e. a total cost of €7.3 to €8.1, excluding VAT. Sometimes this solution turns out to be less effective and constant monitoring is required to prevent the terminal buds from growing laterally through the wide mesh.

The cheapest option is a **plastic mixed-mesh tree guard** (250 g/m²) fixed to two stakes: 2.1 to 2.5 € (excl. VAT) for the mesh (ht 180 cm, Ø 30-33 cm) and 1.10 to 1.19 € (excl. VAT) per locustwood stake (L 210 cm, S 28 x 28 mm), making a total of 4.3 to 4.9 € (excl. VAT). If red deer density is high, a better solution would be a reinforced double mesh fixed to two more robust stakes (L 200 to 250 cm, Ø 4-6 or, better, 6-8 cm) in natural wood, or possibly treated pine **(Photo 59)**.

We recommend heavily galvanised (class C, 270 g zinc/m²) wire mesh (horizontal wires Ø: 2.5 to 3 mm; selvedge wires Ø: 2.5 to 3.4 mm) fencing made of widening, woven mesh sections (Cyclone®: mesh size 89 to 178 mm from the bottom to the top; Ursus® heavy AS: mesh size 75 to 200 mm; Rempart®: 76 to 203 mm).

The mesh is fastened to one or two fence-posts to form an oval section around the plant, or to three or four posts to form a triangle or a square. These should be sturdy pointed posts (ht 250 cm, Ø 6-8 or 8-10 cm) in natural or treated wood, and placed at least a 1.5 m apart **(Photo 57)**. The fencing is nailed to the outside of the posts and closed with barbed, U-shaped fence staples. The barbs keep the staples from being pushed out once they have been nailed in.

To prevent red deer damage, a 200-cm high individual fence is recommended. To lower the overall cost of this rather expensive type of protection **(Tip 4)**, the mesh can be cut to a height of 180 cm and placed 20 cm above the ground to make it easier to remove weeds around the base of the tree.

On mountains and in areas with heavy snowfall, it is better to use highly resistant fencing 200 cm in height made with heavily galvanised 3 mm wire.

On tall trunks, we recommend coating the first primary lateral branches with lime to make them less palatable, because red deer can rear up on their hind legs to reach and browse on them, and can even snap off the top by pulling on it. In terms of maintenance, the base of the tree should be kept weed free and pruning has to done by inserting the secateurs through the mesh.

Fine-mesh (≤ 4 mm) wind-resistant tree guard

Plastic tree guards in fine, wind-resistant mesh are used for total protection of all broadleaved **(Photo 60)** or fast-growing softwood species with flexible branches (Douglas fir, larch) from all kinds of rabbit, hare and roe deer damage (this type of mesh may not be sturdy enough to resist high roebuck

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pressure). They can provide partial protection from rubbing on large broadleaved trees, conifers and poplar saplings **(Photo 61)**. They are not recommended for red deer.

These tree guards are characterised by their fine mesh (< 5 mm). The manufacturing process, developed in the 1980s, resolves the two disadvantages of wide-mesh tree guards (shoots cannot grow out sideways, main stems are not browsed or malformed). For beeches, which have pointed buds, the mesh must be smaller than 3 mm to prevent the main stem from growing through the sides, with the risk of malformation **(Photo 62)** and browsing.

These tree guards are sold as preformed sleeves tubes (Ø 12.5 to 30 cm) and should be made of polyethylene treated with an anti-UV agent (avoid polypropylene). They are delivered flat to reduce bulk and weight, facilitating transport and storage.

They are quickly installed by sliding them down the tree around two bamboo stakes (ht 60 or 90 cm), to protect it from rabbits (large end Ø 6-8 mm) and hares (Ø 8-10 mm), or by stapling them to a pointed wooden stake (ht 150 cm, S 22 x 22 mm or C 9-11 cm) to protect it from roe deer.

58 - Ultra-wide diamond-shaped mesh tree guard (ht 180 cm, Ø 30 cm) attached to 2 industrial treated pine posts (L 250 cm, Ø 6-8 cm) to prevent red deer damage to a pedunculate oak.

59 - Mixed-mesh (59.1) or reinforced double-mesh (59.2) tree guards (ht 180 cm, Ø 30 cm) attached to 2 industrial treated pine posts (L 250 cm, Ø 6-8 cm) to prevent red deer damage to a pedunculate oak.

60 - A Norway maple protected from roe deer damage by a standard (200 g/m²) fine-mesh plastic tree guard (ht 120 cm, Ø 14 cm) on chestnut stake (L 150 cm, C 9-11 cm).

61 - A standard (200 g/m²) fine-mesh plastic tree guard (ht 110 cm, Ø 10 cm) for partial protection of a poplar from buck rubs.

62 - The stem of a young beech has a natural tendency to curve and bend towards the ground and will twist as it grows inside a small-diameter fine-mesh plastic tree guard. If a fine mesh is used, the tree guard should therefore be at least 20 cm in diameter and attached to 2 stakes to maintain its oval shape.

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In very windy regions, it is advisable to strengthen these tree guards with a bamboo stake (L 120 cm, large end Ø 8/10 or 10/12 mm).

These tree guards will gradually stretch and tear without injuring the tree as it grows in girth (on thin-barked trees, they may leave marks with no ill effects).

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63 - A Norway maple protected from roe deer damage by a heavyweight (400 g/m²) reinforced mixed-mesh plastic tree guard (ht 120 cm, Ø 15 cm).

64 - A larch protected from roe deer damage by a heavyweight (420 g/m²) reinforced mixed-mesh plastic tree guard (ht 120 cm, Ø 30 cm).

65 - Mixed-mesh plastic tree guards are not recommended around poplars (fine bark and rapid growth). The mesh weight (Ø 14-15 cm) must be less than 260 g/m² to ensure that it gradually tears.

66 - This mixed-mesh tree guard (ht 120 cm, Ø 20 cm) will stretch (66.1) and gradually tear (66.2) as the trunk grows in girth.

Mixed and/or reinforced mesh tree guard

To help protect hardwoods **(Photo 63)**, softwoods **(Photo 64)** or poplar saplings **(Photo 65, Photo 66)** from deer damage, several models of double-mesh or reinforced mixed-mesh tree guards are now marketed.

These combine the advantages of wide and fine mesh: the thick plastic strands, generally forming a 1 cm to 3 cm mesh, provide rigidity, while the fine mesh (2 to 3 mm) prevents shoots from growing through the sides, thus considerably reducing the risks of malformation and browsing of the main stems.

Thanks to their excellent rigidity and high resistance to wind and snow, tree guards in heavyweight, reinforced double mesh are very durable. They can be used to control the less severe types of red deer damage to hardwoods.

They need to be inspected for stretching **(Photo 44)** and tearing as the mesh comes into contact with the tree **(Photo 66)**. A lighter (medium weight) mixed mesh is preferable for poplars.

Partial protection

Spiral tree guard

Spiral tree guards differ from mesh guards. They are made from single-walled, semi-rigid to rigid sheets of beige, white, or brown plastic perforated with staggered rows of ventilation holes to reduce risks of insect or fungus infestations. They are designed to be wound directly around a tree that has already been planted.

They are made of polypropylene (avoid products made with chlorine derivatives because of pollution) and are sold pre-cut into spiral strips (Ø 4 cm) that are compact and easy to transport.

They can be installed quickly and easily by winding them (from bottom to top) around the stem. They are rigid enough to stay in place and therefore do not need to be staked. As the tree grows in girth, the spiral should gradually loosen without strangling the tree.

Used in the past by foresters to protect newly planted poplar seedlings, spiral tree guards are now sometimes used in parklands or orchards for large hardwoods with no low-growing lateral branches, for protection against bark gnawing by hares and rabbits and rubbing by roebucks.

However, they are not recommended because of their numerous drawbacks **(Photo 67)**:

- because the polypropylene deteriorates rapidly, the spiral often loses its rigidity, and therefore its effectiveness, and drops like a sock to the base of the tree;
- the spiral is only effective for a very short time (± 2 years) because its diameter is too small: as the trunks of fast-growing tree species grow in girth, they push out the spiral, causing it to fall away too soon;
- sometimes the spiral is too rigid to expand as the tree grows in girth. The consequences are marks on the bark and in certain extreme cases, embedding in the wood **(Photo 68)**, which causes irreversible damage (weakened trunks, secondary pest[3] infestations);
- if the mesh comes into close contact with the tree, the lack of ventilation of the stem and overheating of the plastic during heatwaves can cause burns on fine bark.

[3] Undesired insect species that kill trees and attack mainly weak or dying trees. They often accelerate the process of degradation and weakening of the tree.

67 - When a plastic spiral tree guard is too rigid, it can mark the bark, and especially favour the development of cankers that can impair the technological quality of the wood.

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68 - Strangling damage to a poplar caused by a spiral which is too rigid.

69 - A mesh (90 g/m²) tree guard (ht 110 cm, Ø 11 cm) wrapped around a sapling with no low-growing lateral branches to protect it from roe deer damage.

Fine-mesh (3 mm) tree wrap

This kind of tree guard is a sheet (ht 55-110 cm) of fine mesh (3 mm) that wraps around the stem (ø 6, 11, or 15 cm). It is designed to protect poplars and large hardwoods with no low-growing lateral branches from bark gnawing by hares and rabbits and rubbing by roebucks (provided the game density is low). The mesh is made of shape-memory heat-workable plastic that will close itself around the trunk **(Photo 69)**, protecting it from animal damage.

Packaged in bags of 75 to 150, these polypropylene mesh tree guards are compact and easy to transport. They can be installed quickly and simply by wrapping them around the stem of young trees, without the need for staples or stakes as they are self-closing **(Photo 69).**

Mesh tree wraps are preferable to spiral guards for several reasons:

- the mesh ensures that the enclosed tree inside is always properly ventilated, thus preventing infestations of insect pests and parasitic fungi;
- as the wrap is split lengthways, it will not sag to the base of the plant and therefore provides lasting protection;
- it opens up gradually and according to the irregularities of the trunk as the tree grows in girth, so that there is no risk of strangulation;
- it is easy and quick to remove and can be re-used.

The diameter must be chosen on the basis of the juvenile growth rate of the tree to be protected. If the cross-section is too small (Ø 6 cm), the tree wrap will open and fall to the ground too soon for rapidly-growing species (cherry, poplar).

Expandable ultra-wide mesh tree guard

Expandable mesh tree wraps are supplied as wraparound sleeves (ht 180 cm, perimeter 45 or 78 cm) of wide, diamond-shaped mesh (15 mm) and will expand to three times their original width. This type of tree guard is designed to protect young saplings and pruned mature hardwoods and softwoods from bark stripping by red deer **(Photo 38)**.

The pre-cut, low-density black polyethylene sleeves come in packages of 50 and are wrapped around the pruned trunk **(Photo 70)**.

Thanks to the highly expandable mesh, these tree guards can be used to protect trees of varying girths. The mesh expands with the growth of the tree and tears at the right point (Ø of the trunk ca. 40 cm) without damaging the wood.

They are closed by stapling together the vertical strands along the selvedges with Omega® galvanised staples (which resist opening even under heavy pressure) every 15 cm. A special hand-held stapler is used **(Photo 71)**.

A specially adapted version for protecting newly planted poplars from rubbing by roebucks is made of expandable diamond-shaped mesh (ht 120 cm and ø 7 cm) capable of expanding to three times its original diameter.

These low-density black polyethylene tree guards come in packages of 25 sheets or in 50 m rolls to be cut to size. They are wrapped around the saplings before planting **(Photo 72)**. They can be installed very quickly, as there is no need for staples or stakes.


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Colour

Tree guards come in a wide range of colours. The most common are black, blue and green, but some are supplied in dark brown, beige, grey and other colours.

The colour has no effect on the growth of the trees, so the choice will mainly depend on its impact on the landscape, which must be minimal. In general, the best choice is black or green, since these colours blend in best with the vegetation.

In the same product line, however, the colour affects the final cost: blue and green tree guards are 2.5 % to 3 % and 7 % to 8 % more expensive, respectively, than black ones.

Some people claim that bright colours are better deterrents to animals. However, there is no known study confirming this hypothesis, and mammals cannot distinguish the different colour shades of objects very well. The main reason for bright colours is to make the tree rows easier to see, thus facilitating mechanised maintenance work or hand weeding.

Actual costs

In forests, no protection is 100 % effective, except at prohibitive cost. A damage tolerance threshold has to be accepted, based on planting density and on the cost of protection. In agroforestry, investing in tree guards is essential.

A given product may seem expensive to buy, but may make more economic sense than a cheap system that has to be replaced after two years or takes longer to install. All costs therefore need to be considered when making the choice: purchase price, installation time, performance, durability, side effects and eventual removal.

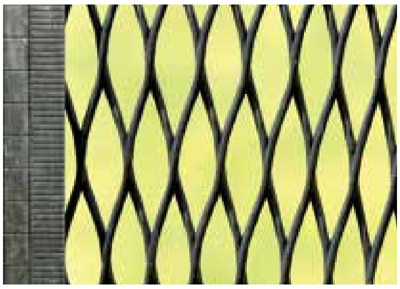
The actual cost of a tree guard (Table 5), including delivery and installation, depends on several factors: the type of tree guard (Table 6), and especially the weight of the mesh (Tip 5), and also on the sales policies of manufacturers and dealers.

70 - The expandable mesh is closed around the tree by stapling the vertical strands (70.1) of the edges together with metal staples about every 15 cm (70.2).

71 - OMEGA® stapler and galvanised staples.

72 - This expandable tree guard (72.1) of wide, diamond-shaped mesh (72.2) will expand to three times its original diameter (72.3).


72.1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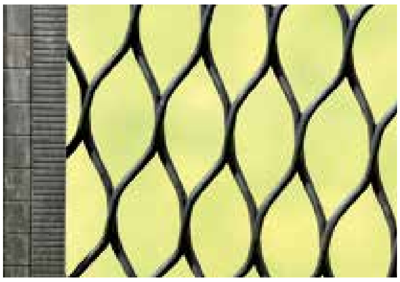
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Tip 5 - Choose the heavier weights

Within each weight range, foresters and farmers have a choice between different products with fairly similar technical specifications (height, diameter, mesh size).

We strongly recommend choosing the heavier weights over lighter and less expensive products.

Type of tree guard

This is defined by:

- the mesh type: metal, wide-meshed or fine-meshed plastic (wind-resistant mesh ≤ 4 mm);
- height: standard heights are 50 cm (for rabbits), 60 cm (for hares), 120 cm (for roe deer), and 180 cm (for red deer). Depending on the brand, other heights are also available: 55, 80, 90, 100, 110, 150, 200, 210 cm;
- diameter: 14-15 cm on average for hardwoods; tree guards for softwoods have the widest diameters (20 cm to 33 cm). Split tree guards (tree wraps) for large broadleaved species or poplars are at least 11 cm in diameter.

Sales policy

This determines:

- quantities: prices are lower when products are ordered in large quantities. Moreover, the price breakdown by quantity varies with each manufacturer according to their sales policies. Some manufacturers sell their product lines through a national network of dealers (nursery growers, cooperatives, contractors, etc.);
- direct sales: supplies can sometimes be purchased directly from the manufacturer **(Tip 6)**. It is a good idea to ask their sales department for bulk prices (> 10,000 units), which are frequently ad hoc. Sometimes this is also worth doing for small orders (< 2,000 units);
- shipping costs: these vary according to distance from 4 % to 16 % of the unit sale price of tree shelters. Some orders may be delivered free, depending on the quantity or the amount invoiced.

Choosing a dealer

For any given product, the differences in prices between two dealers are likely to vary one way or the other according to quantities ordered and business relationships. It is worth contacting different dealers for quotations before placing an order.

Other factors to consider are proximity (as the dealer is liable for problems in managing, shipping and handling orders) and whether after-sales services and technical advice are provided, especially for new products on the market.

Table 5 - Average price in € excluding VAT (2014-15 season)

TYPE OF PROTECTION	WEIGHT RANGE	MESH
Total protection (and partial for certain models)	Light (≤ 150 g/m^2)	Wide mesh (≥ 5 mm)
		Fine mesh (≤ 4 mm)
	Standard (± 200 to 250 g/m^2)	Fine mesh (≤ 4 mm)
	Medium (± 250 to 350 g/m^2)	Fine mesh (≤ 4 mm)
		Double mesh
		Ultra-wide mesh (≥ 15 mm)
	Heavy (± 400 to 450 g/m^2)	Reinforced double mesh
	Ultra-heavy (≥ 500 g/m^2)	Wide mesh (≥ 5 mm)
Partial protection	Standard (± 200 à 250 g/m^2)	Fine mesh (≤ 4 mm)
		Wide mesh
	Heavy (± 400 to 450 g/m^2)	Wide mesh (≥ 5 mm)

of mesh tree guards for protecting trees from animal damage

HEIGHT (CM)	DIAMETER (CM)	WEIGHT (G/M²)			UNIT PRICE IN € (CATALOGUE PRICE)	PRODUCT RANGE
		Griplast	Nortène Internas	Samex		
50	14 - 15	91	91, 107	95	0.08 - 0.10	Stoplièvre, Dissuasion 40 g (47 g), Protectnet (+), Standard
	24 - 25	93	90	89	0.14 - 0.16	Stoplièvre, Dissuasion Ø 24, Paysanet Ø 24, Espaces verts
	30	74	-	117	0.20 - 0.30	Stoplièvre, Espaces verts
60	14 - 15	91	91, 107	95	0.09 - 0.13	Stoplièvre, Dissuasion 40 g et 47 g, Protectnet (+), Standard
	17	-	187	-	0.53 - 0.62	Dissuasion Bio, Paysanet Bio
	24 - 25	93	90	89	0.17 - 0.20	Stoplièvre, Dissuasion Ø 24, Paysanet Ø 24, Espaces verts
	30	74	72	117	0.19 - 0.23	Stoplièvre, Dissuasion Ø 30, Paysanet Ø 30, Espaces verts
50	14	-	148	-	0.12 - 0.14	Dissuasion 65 g, Protectnet 65 g
60	10	-	-	143	0.30 - 0.45	Brise-vent
	14 - 15	193	193	159	0.26 - 0.30	Brocarstop, Climatic simple, Micronet
	14	-	227	-	0.53 - 0.63	Climatic Bio, Micronet Bio
	20	207	207	159	0.40 - 0.47	Brocarstop, Climatic simple, Micronet, Brise-vent
	30	-	255	212	0.46 - 0.55	Climatic simple, Micronet, Brise-vent
100 - 110	10 - 12.5	216, 239	207	-	0.36 - 0.42	Brocarstop, Climatic simple, Micronet
120	10 - 12.5	216, 239	-	143	0.43 - 0.50	Brocarstop, Brise-vent
	14 - 15	193	193	159	0.48 - 0.57	Brocarstop, Climatic simple, Micronet
	14	-	227	-	1.06 - 1.26	Climatic Bio, Micronet Bio
	20	207	207	159	0.73 - 0.86	Brocarstop, Climatic simple, Micronet
	30	233. 255	255	212	1.19 - 1.40	Brocarstop, Climatic simple, Micronet, Brise-vent
150	10	-	-	143	0.43 - 0.50	Brise-vent
	14 - 15	-	193	159	0.60 - 0.71	Climatic simple, Micronet, Brise-vent
	20	-	207	159	0.91 - 1.08	Climatic simple, Micronet, Brise-vent
	30	-	255	212	1.49 - 1.75	Climatic simple, Micronet, Brise-vent
180	30	-	255	-	1.79 - 2.10	Climatic simple, Micronet
60	12	-	371	-	0.43 - 0.50	Climatex, Climatplant
110	10	-	255	-	0.40 - 0.47	Climatic mixte
120	12.5	229	-	-	0.50 - 0.55	Brocarstop+
	14	250	250	-	0.56 - 0.66	Brocarstop+, Climatic mixte, Climanet
	20	302	302	-	0.96 - 1.13	Brocarstop+, Climatic mixte, Climanet
	30	276, 318	297	-	1.43 - 1.68	Brocarstop+, Climatic mixte, Climanet
150	14	-	250	-	0.70 - 0.82	Climatic mixte, Climanet
180	20	-	302	-	1.45 - 1.70	Climatic mixte, Climanet
210	30	-	255	-	2.50 - 2.94	Climatic mixte, Climanet
120	30 - 33	318	289	-	1.50 - 1.76	Conifprotect, Grandes mailles
180	30 - 33	318	338	-	2.49 - 2.93	Conifprotect, Grandes mailles
120	15	403	403	382	1.11 - 1.30	Brocarstop+, Climatic ***, Climanet+, Brise-vent renforcée
	20	-	414	382	1.47 - 1.73	Climatic ***, Climanet +, Brise-vent renforcée
	30	-	424	-	2.15 - 2.53	Climatic ***, Climanet +
150	15	-	403	382	1.38 - 1.63	Climatic ***, Climanet +, Brise-vent renforcée
	20	-	414	382	1.84 - 2.16	Climatic ***, Climanet +, Brise-vent renforcée
180	15	-	403	382	1.66 - 1.95	Climatic ***, Climanet +, Brise-vent renforcée
	20	-	414	382	2.20 - 2.59	Climatic ***, Climanet +, Brise-vent renforcée
	30	-	424	-	3.35 - 3.95	Climatic ***, Climanet +
150	20	-	716	-	2.47 - 2.90	Climatic Agro
180	30	-	716	-	2.96 - 3.48	Climatic Agro
55	11	-	231	-	0.31 - 0.37	Surtronc, Treex
	15	-	263	-	0.37 - 0.43	Surtronc, Treex
80	11	-	231	-	0.45 - 0.54	Surtronc, Treex
	15	-	263	-	0.52 - 0.61	Surtronc, Treex
110	11	-	231	-	0.62 - 0.74	Surtronc, Treex
	15	-	263	-	0.71 - 0.84	Surtronc, Treex
120	7 (- 25)	-	(156 g/u)	-	0.75 - 0.88	Gaine extensible, Cerviflex
180	25 (- 75)	-	(410 g/u)	-	2.21 - 2.72	Balivocerf, Cervipro

See **Table 8** (p. 51) to choose the right supports for each type of tree guard.

Table 6 - Technical specifications and uses of mesh tree guards

Protection: Total	Protection: Partial	Weight range	Mesh type	Company	Designation	Black	Blue	Green	Dark brown	Beige	Height (cm)	Diameter (cm)	Mesh size (mm)	Weight (g/ml)	Weight (g/m²)	Weight (g/unit)	Hardwoods	Schrubs	Poplars	Softwoods	Rabbits	Hares	Roe deer	Red deer
■		Light (≤ 150 g/m²)	Wide mesh (≥ 5 mm)	Intermas	DISSUASION 40 G	X	X	X			50	14	8 x 8	40	91	20	■				■			
■				Griplast	STOPLIEVRE		X				50	14	8 x 8	40	91	20	■				■			
■				Intermas	DISSUASION 47 G	X					50	14	8 x 8	47	107	24	■				■			
■				Samex	STANDARD	X	X	X	X	X	50	15	5 x 5	45	95	23	■				■			
■				Samex	STANDARD	X	X	X	X	X	50	15	10 x 10	45	95	23	■				■			
■				Intermas	DISSUASION Ø 24			X			50	24	8 x 8	68	90	34	■	■		■	■			
■				Griplast	STOPLIEVRE		X				50	24	8 x 8	70	93	35	■	■		■	■			
■				Samex	ESPACES VERTS	X	X	X	X		50	25	8 x 8	70	89	35	■	■		■	■			
■				Griplast	STOPLIEVRE		X				50	30	8 x 8	70	74	35	■	■		■	■			
■				Samex	ESPACES VERTS	X	X	X	X		50	30	5 x 5	110	117	55	■	■		■	■			
■				Intermas	DISSUASION 40 G	X	X	X			60	14	8 x 8	40	91	24	■				■	■		
■				Griplast	STOPLIEVRE		X				60	14	8 x 8	40	91	24	■				■	■		
■				Intermas	DISSUASION 47 G	X					60	14	8 x 8	47	107	28	■				■	■		
■				Samex	STANDARD	X	X	X	X	X	60	15	5 x 5	45	95	27	■				■	■		
■				Samex	STANDARD	X	X	X	X	X	60	15	10 x 10	45	95	27	■				■	■		
■				Intermas	DISSUASION BIO	X					60	17	8 x 8	100	187	60	□				□	□		
■				Intermas	DISSUASION Ø 24			X			60	24	8 x 8	68	90	41	■	■		■	■	■		
■				Griplast	STOPLIEVRE		X				60	24	8 x 8	70	93	42	■	■		■	■	■		
■				Samex	ESPACES VERTS	X	X	X	X		60	25	8 x 8	70	89	42	■	■		■	■	■		
■				Intermas	DISSUASION Ø 30			X			60	30	8 x 8	68	72	41	■	■		■	■	■		
■				Griplast	STOPLIEVRE		X				60	30	8 x 8	70	74	42	■	■		■	■	■		
■				Samex	ESPACES VERTS	X	X	X	X		60	30	5 x 5	110	117	66	■	■		■	■	■		
■			Fine mesh	Intermas	DISSUASION 65 G				X		50	14	4 x 4	65	148	33	■				■			
	■	Standard (± 200 to 250 g/m²)	Fine mesh (≤ 4 mm)	Samex	BRISE-VENT	X	X	X	X		60	10	3 x 3	45	143	27	■				■	■		
■				Intermas	CLIMATIC SIMPLE	X					60	14	2 x 2	85	193	51	■				■	■		
■				Griplast	BROCARSTOP	X					60	14	2 x 2	85	193	51	■				■	■		
■				Intermas	CLIMATIC BIO	X					60	14	3 x 3	100	227	60	□				□	□		
■				Samex	BRISE-VENT	X	X	X	X		60	15	3 x 3	75	159	45	■				■	■		
■				Samex	BRISE-VENT	X	X	X	X		60	20	3 x 3	100	159	60	■	■		■	■	■		
■				Intermas	CLIMATIC SIMPLE	X					60	20	3 x 3	130	207	78	■	■		■	■	■		
■				Griplast	BROCARSTOP	X					60	20	2 x 2	130	207	78	■	■		■	■	■		
■				Samex	BRISE-VENT	X	X	X	X		60	30	3 x 3	200	212	120	■	■		■	■	■		
■				Intermas	CLIMATIC SIMPLE	X					60	30	4 x 4	240	255	144	■	■		■	■	■		
	■			Griplast	BROCARSTOP	X					100	10	2 x 2	75	239	75			■		■	■	■	
	■			Griplast	BROCARSTOP	X					100	12.5	2 x 2	85	216	85			■		■	■	■	
	■			Intermas	CLIMATIC SIMPLE	X					110	10	2 x 2	65	207	72			■		■	■	■	
	■			Samex	BRISE-VENT	X	X	X	X		120	10	3 x 3	45	143	54			■		■	■	■	
	■			Griplast	BROCARSTOP	X					120	10	2 x 2	75	239	90			■		■	■	■	
	■			Griplast	BROCARSTOP	X					120	12.5	2 x 2	85	216	102			■		■	■	■	
■	■			Intermas	CLIMATIC SIMPLE	X					120	14	2 x 2	85	193	102	■		■		■	■	■	
■	■			Griplast	BROCARSTOP	X					120	14	2 x 2	85	193	102	■		■		■	■	■	
■	■			Intermas	CLIMATIC BIO	X					120	14	3 x 3	100	227	120	□		□		□	□	□	
■	■			Samex	BRISE-VENT	X	X	X	X		120	15	3 x 3	75	159	90	■		■		■	■	■	
■				Samex	BRISE-VENT	X	X	X	X		120	20	3 x 3	100	159	120	■	■		○	■	■	■	
■				Intermas	CLIMATIC SIMPLE	X					120	20	3 x 3	130	207	156	■	■		○	■	■	■	
■				Griplast	BROCARSTOP	X					120	20	2 x 2	130	207	156	■	■		○	■	■	■	
■				Samex	BRISE-VENT	X	X	X	X		120	30	3 x 3	200	212	240	■	■		○	■	■	■	
■				Griplast	BROCARSTOP	X					120	30	2 x 2	220	233	264	■	■		○	■	■	■	
■				Intermas	CLIMATIC SIMPLE	X					120	30	4 x 4	240	255	288	■	■		○	■	■	■	
■				Griplast	BROCARSTOP	X					120	30	2 x 2	240	255	288	■	■		○	■	■	■	
	■			Samex	BRISE-VENT	X	X	X	X		150	10	3 x 3	45	143	68	□				□	□	□	
■				Intermas	CLIMATIC SIMPLE	X					150	14	2 x 2	85	193	128	■				■	■	■	
■				Samex	BRISE-VENT	X	X	X	X		150	15	3 x 3	75	159	113	■				■	■	■	
■				Samex	BRISE-VENT	X	X	X	X		150	20	3 x 3	100	159	150	■			○	■	■	■	
■				Intermas	CLIMATIC SIMPLE	X					150	20	3 x 3	130	207	195	■			○	■	■	■	
■				Samex	BRISE-VENT	X	X	X	X		150	30	3 x 3	200	212	300	■			○	■	■	■	
■				Intermas	CLIMATIC SIMPLE	X					150	30	4 x 4	240	255	360	■			○	■	■	■	
■				Intermas	CLIMATIC SIMPLE	X					180	30	4 x 4	240	255	432	■			○	■	■	■	□

■ RECOMMENDED □ POSSIBLE ○ ONLY FOR VERY FAST GROWING SOFTWOODS WITH FLEXIBLE BRANCHES (DOUGLAS FIR, LARCH)

Table 6 (continued) - Technical specifications and uses of mesh tree guards

Protection: Total	Protection: Partial	Weight range	Mesh type	Company	Designation	Black	Blue	Green	Dark brown	Beige	Height (cm)	Diameter (cm)	Mesh size (mm)	Weight (g/ml)	Weight (g/m²)	Weight (g/unit)	Hardwoods	Schrubs	Poplars	Softwoods	Rabbits	Hares	Roe deer	Red deer
■		Medium (± 250 to 350 g/m²)	Fine mesh	Intermas	CLIMATEX	X					60	12	2 x 2 + reinforcements	140	371	84	■				■	■		
	■		Double mesh	Intermas	CLIMATIC MIXTE						110	10	27 x 27 / 3 x 3	80	255	88			■		■	■	■	
	■			Griplast	BROCARSTOP +	X					120	12,5	3 x 3	90	229	108			■		■	■	■	
■	■			Intermas	CLIMATIC MIXTE	X					120	14	27 x 27 / 3 x 3	110	250	132	■		■		■	■	■	
■	■			Griplast	BROCARSTOP +	X					120	14	3 x 3	110	250	132	■		■		■	■	■	
■				Intermas	CLIMATIC MIXTE						120	20	27 x 27 / 3 x 3	190	302	228	■	□		○	■	■	■	
■				Griplast	BROCARSTOP +						120	20	3 x 3	190	302	228	■	□		○	■	■	■	
■				Griplast	BROCARSTOP +	X					120	30	3 x 3	260	276	312	■	□		○	■	■	■	
■				Intermas	CLIMATIC MIXTE						120	30	27 x 27 / 3 x 3	280	297	336	■	□		○	■	■	■	
■				Griplast	BROCARSTOP +	X					120	30	3 x 3	300	318	360	■	□		○	■	■	■	
■				Intermas	CLIMATIC MIXTE	X					150	14	27 x 27 / 3 x 3	110	250	165	■				■	■	■	
■				Intermas	CLIMATIC MIXTE						180	20	27 x 27 / 3 x 3	190	302	342	■			○	■	■	■	□
■				Intermas	CLIMATIC MIXTE	X					210	30	27 x 27 / 3 x 3	240	255	504	■			○	■	■	■	■
■			Ultra-wide mesh (≥ 15 mm)	Griplast	CONIFPROTECT	X					120	30	20 x 20	300	318	360	□	□		○	■	■	■	
■				Intermas	GRANDES MAILLES	X					120	33	20 x 20	300	289	360	□	□		○	■	■	■	
■				Griplast	CONIFPROTECT	X					180	30	20 x 20	300	318	540	■			○	■	■	■	■
■				Intermas	GRANDES MAILLES						180	33	20 x 20	350	338	630	■			○	■	■	■	■
■		Heavy (± 400 to 450 g/m²)	Reinforced double mesh	Samex	BRISE-VENT RENFORCEE	X			X		120	15	3 x 3	180	382	216	■				■	■	■	
■				Griplast	BROCARSTOP +	X					120	15	3 x 3	190	403	228	■				■	■	■	
■				Intermas	CLIMATIC ***	X					120	15	25 x 25 / 2.5 x 2.5	190	403	228	■				■	■	■	
■				Samex	BRISE-VENT RENFORCEE	X			X		120	20	3 x 3	240	382	288	■	□		○	■	■	■	
■				Intermas	CLIMATIC ***	X					120	20	25 x 25 / 2.5 x 2.5	260	414	312	■	□		○	■	■	■	
■				Intermas	CLIMATIC ***	X					120	30	25 x 25 / 2.5 x 2.5	400	424	480	■	□		○	■	■	■	
■				Samex	BRISE-VENT RENFORCEE	X			X		150	15	3 x 3	180	382	270	■				■	■	■	
■				Intermas	CLIMATIC ***	X					150	15	25 x 25 / 2.5 x 2.5	190	403	285	■				■	■	■	
■				Samex	BRISE-VENT RENFORCEE	X			X		150	20	3 x 3	240	382	360	■			○	■	■	■	
■				Intermas	CLIMATIC ***	X					150	20	25 x 25 / 2.5 x 2.5	260	414	390	■			○	■	■	■	
■				Samex	BRISE-VENT RENFORCEE	X			X		180	15	3 x 3	180	382	324	■			○	■	■	■	□
■				Intermas	CLIMATIC ***	X					180	15	25 x 25 / 2.5 x 2.5	190	403	342	■				■	■	■	□
■				Samex	BRISE-VENT RENFORCEE	X			X		180	20	3 x 3	240	382	432	■				■	■	■	□
■				Intermas	CLIMATIC ***	X					180	20	25 x 25 / 2.5 x 2.5	260	414	468	■				■	■	■	□
■				Intermas	CLIMATIC ***	X					180	30	25 x 25 / 2.5 x 2.5	400	424	720	■				■	■	■	■
■		Ultra-heavy (> 500 g/m²)	Wide mesh	Intermas	CLIMATIC AGRO	X					150	20	5 x 5	450	716	675	■				■	■	■	
■						X					180	20	5 x 5	450	716	810	■				■	■	■	□
	■	Standard (± 200 to 250 g/m²)	Fine mesh (≤ 4 mm)	Intermas	SURTRONC	X					55	11	3 x 3	80	231	44	■		■		■			
	■			Intermas	SURTRONC	X					55	15	3 x 3	124	263	68	■		■		■			
	■			Intermas	SURTRONC	X					80	11	3 x 3	80	231	64	■		■		■	■		
	■			Intermas	SURTRONC	X					80	15	3 x 3	124	263	99	■		■		■	■		
	■			Intermas	SURTRONC	X					110	11	3 x 3	80	231	88	□		□		□	□	□	
	■			Intermas	SURTRONC	X					110	15	3 x 3	124	263	136	□		□		□	□	□	
	■		Wide mesh	Intermas	GAINE EXTENSIBLE	X					120	7 (-25)	15 x 15	-	-	156			□		□	□	□	
	■	Heavy (± 400 to 450 g/m²)	Wide mesh (≥ 15 mm)	Intermas	BALIVOCERF						180	25 (-75)	20 x 20	-	-	410	■			■	■	■	■	■

■ RECOMMENDED □ POSSIBLE ○ ONLY FOR VERY FAST GROWING SOFTWOODS WITH FLEXIBLE BRANCHES (DOUGLAS FIR, LARCH)

73.1

73.2

Tip 6 - Useful addresses

Manufacturers of mesh tree guards for protecting trees from animal damage sell their products through distribution networks (nursery growers, cooperatives, contractors) in several European Union countries.

For the sake of simplicity and clarity, only French addresses are given in this guide. Please contact the manufacturers at the following addresses to find a dealer or dealers in a particular country or region in Europe.

GRIPLAST INT.
Tel: +33 (0)2 41 75 06 06
Email: info@griplast.com
Web site: www.griplast.com

INTERMAS AGRICULTURE CELLOPLAST S.A.S.
Tel: +33 (0)2 43 64 14 14
Email: info@celloplast.fr
Web site: www.intermas.com

SAMEX
Tel: +33 (0)2 43 97 48 53
Email: samex@samex.fr
Web site: www.samex.fr

NORTÈNE TECHNOLOGIES, S.A.S.
Tel: +33 (0)3 20 08 05 89
Email: contact@netten.fr
Web site: www.netten.fr

73 - Split pointed chestnut (73.1) stakes (L 150 cm, C 18/22 cm) supporting a heavy (400 g/m²) reinforced double mesh (73.2) tree guard (ht 120 cm, Ø 15 cm). If stakes of this type are to be driven into the ground in the conventional way, the operation should be mechanized as far as possible, i.e., using a front-end bucket on a farm tractor (73.3, 73.4 and 73.5).

73.5

73.3

73.4

Choosing the right supporting stakes

To ensure durability and stability, a mesh tree guard must be fastened to one or more good quality stakes. The useful life of the stakes depends on the material, on their cross-section and on many other factors including soils, climate and the exposure of the planting site. Four types of stakes with different quality characteristics can be used.

Basic materials

The performance of a tree guard mainly depends on its durability and resistance to wind, and therefore on the quality of the stakes used.

Four types of stakes made of metal, bamboo or wood can be used to fix and support mesh tree guards.

Metal stake

Metal stakes are serrated steel reinforcement bars (rebar) 65 cm to 100 cm in length with a constant diameter of 4 mm **(Photo 74)**. They come in packs of 100, which weigh around 8 kg on average. We recommend storing them in a dry place because the non-galvanised steel from which they are made will rust in the rain.

They are thin, and therefore compact, but sturdy, and do not bend during installation. They are durable (more than 10 years) and can be readily reused if handled with gloves when they get rusty.

The top 5 cm is curved to fit over the tree shelter. The curved ends prevent injuries to workers in the event of a fall, make installation easier without potential injury to the hands, and hold the tree guard firmly in place around the plant, preventing animals and wind from lifting it and tearing it away.

Rebars with bevelled bottom ends are recommended because they are easier to drive through thick fibre mulch mats [(4)].

Metal stakes are used to anchor lightweight rabbit guards (Ø 4 mm, L 70 cm) and hare guards (Ø 4 mm, L 80 cm) on stony ground, in windy parklands **(Photo 75)** and in vineyards, and when re-establishing tree cover along abandoned roads or railways. They are not recommended for forest use **(Photo 76)** because they are a hazard for subsequent mechanised weeding around young trees or log hauling unless they are removed beforehand.

74 - Metal stakes are faster to install than wood or bamboo, but they must be removed when no longer needed.

75 - Metal stakes are curved at the top to hold the tree guard firmly in place around the plant.

76 - Serrated (Ø 8 to 12 mm) steel rebars (L 150 cm) are much more expensive than wooden stakes and are a hazard for people and machines if they are not removed when no longer needed.

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78

Bamboo stake

Bamboo stakes are cheap, lightweight, easy to transport and install, but not very durable. They provide temporary support (1 to 3 years) for lightweight mesh rabbit guards (Ø 6-8 mm, L 60 cm) and hare guards (Ø 6-8 or 8-10 mm, L 90 cm).

They are also used in addition to wooden stakes, especially on windy sites (Ø 8-10 mm, L 120 cm or Ø 10-12 mm, L 150 cm), and to stake out planting rows (Ø 5-6 mm, L 50 cm) or mark trees during weed clearing (Ø 22-24 mm, L 300 cm).

Bamboo stakes are classified by length and diameter at the largest end (the end driven into the ground, **Photo 79.1**) and are made of extra-hard Chinese bamboo **(Tip 7)** from 6-8 mm to 10-12 mm in diameter and 60 cm to 150 cm in length. They are sold in bales of 100, 250, 500, 1000 or 2000 **(Photo 78)**.

Tip 7 - Choosing the right bamboo stakes

Botanically speaking, bamboos are giant, very fast-growing grasses. A bamboo stem is a lignified culm, i.e., a hollow tube partitioned at the leaf nodes.

To fulfil their role, bamboo canes must be inexpensive, sturdy, and durable:

- they are made from the prime Chinese variety known as Tonkin cane (*Pseudosasa amabilis tenuis*), which is extra hard and perfectly straight. Thai bamboo, although sturdy, is not uniform and more suitable for training house plants;
- the hollow centre (or lumen) of the cane is narrow. The thick "wood" ensures resistance to twisting **(photo 77)**;
- the diameter of the small end must be at least equal to 60 % of the diameter of the large end.

Wooden stake

Split or sawn wooden stakes are often used to support tree guards protecting trees from roe deer damage.

They are sold with pointed ends and delivered in bundles. They must not have been treated with preservatives (even for temporary protection) or surface coatings (paint, shellac). They are made from hard woods such as chestnut and locustwood (False acacia).

Chestnut

Chestnut wood *(Castanea sativa Mill.)* is easy to split and therefore often used for stakes with a triangular **(Photo 80)**, rectangular **(Photo 81)** or trapezoid cross-section (L 150 cm, C 9-11).

They last for 3 to 5 years on average. Wood with a high tannin content is resistant to pathogens but deteriorates in bad weather (rotting where the soil is in contact with the air). The smaller the cross-section of the stake, the faster it will rot **(Photo 82)**.

The stake may snap at ground level and drag the tree guard and the tree down with it as it falls **(Photo 83)**. Debarked stakes are recommended to help control chestnut blight[5].

Table 7 - Mechanical characteristics of chestnut and locustwood

	Chestnut	Locust
Mean density at 12 % (g/cm³)	0.59	0.74
Modulus of elasticity in bending (N/mm²)	8 500	13 600
Flexural strength (N/mm²)	71	140
Impact resistance (Nm/cm²)	5.7	12.4

From the French Timber Council (CNDB) - www.cndb.org/?p=fiches_essences

[4] If using metal stakes with no points, starter holes will need to be punched through the mulch mat with a rod two or three times larger in diameter.

79.1

79.2

Locustwood

Locustwood stakes (also called False acacia: *Robinia pseudacacia L.*) are sawn on 4 sides along the grain of the wood. They are square in section (22 x 22 mm, L 80 to 150 cm; 28 x 28 mm, L 210 cm) **(Photo 84)** and naturally more durable than chestnut (5 to 7 years).

They are more resistant to hammering and bending **(Table 7)** and sturdier when driven into stony ground. Nowadays, they are mainly imported from Eastern Europe (Hungary, Romania, etc.). Local supplies are hard to find because stands are sparse and small in area.

False acacia (Locust Tree) is one of the few species that naturally (in the raw state and with no chemical treatment) meets NF EN 335 standard class 4 criteria[6]. The wood can be continuously exposed to humidity, both in and above the ground. Traces of sapwood on the surface may be tolerated **(Photo 85.2)**.

[5] Chestnut trees are attacked by a fungus, *Cryphonectria parasita (*formerly *Endothia parasitica),* commonly known as "chestnut blight", which is found in bark and causes dieback in infected trees.

[6] This standard relates to the durability of wood and defines the basic characteristics of 5 categories of biological pathogen risks to help determine which woods are most suited to different conditions: the higher the index, the better the resistance.

80

81

82

83.1

83.2

77 - The thick "wood" and narrow lumen prevent twisting.

78 - Bamboo stakes imported from China are usually packaged in batches of 1 000.

79 - The larger end (79.1) is driven into the ground. The diameter of the small end (79.2) must be equal to at least 60 % of the diameter of the large end.

80 - Split, debarked and pointed 1.5 m chestnut stakes, with a triangular 9 - 11 cm cross-section, sold in bundles of 50.

81 - Irregular cross-sections are characteristic of sawn chestnut stakes.

82 - The smaller the cross-section of a chestnut stake, the faster it will rot.

83 - Chestnut stakes that are too thin will quickly rot, making the tree guard unstable and compromising the future of the tree.

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85.1

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The most popular: locustwood and chestnut

Stakes and posts are produced by manufacturers who have the right equipment for handling, debarking, splitting and/or sawing and sharpening.

They may purchase roadside logs (raw wood posts sold by the stacked m^3), or harvest standing coppice wood at least 20 to 25 years old, with trunks that are straight and free of defects such as ring shake or canker stain.

The finished products are sold singly to parks and gardens contractors, nursery growers, forestry or agricultural cooperatives, wholesalers and more rarely to retailers.

The round, split or sawn posts are delivered by the truckload, on pallets or in bundles. They are mainly sold for use in vineyards, livestock farms (fencing) and parks and gardens. Prices are highly variable and depend on the type of product and the quantities ordered.

Since posts are finished products, the VAT rate in France is 20 %, not the 10 % rate for firewood.

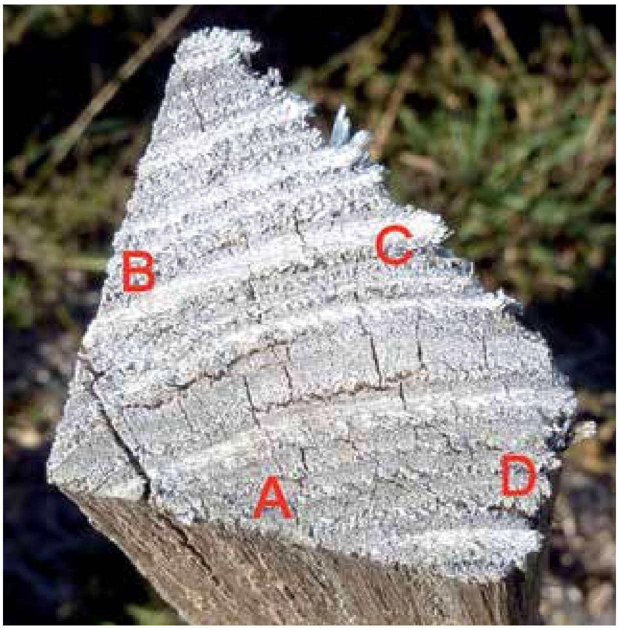
Wooden post

Wooden posts (large-sized stakes) are used as supports for individual tree fences, wooden fences, and/or barbed wire fences protecting forest trees from red deer and field trees from livestock.

Quality criteria include straightness, size and uniformity (in length and circumference), absence of deterioration (especially ring shake, rot and insect boreholes), absence of sapwood, few knots (these must be healthy and small in size). The end to be driven into the ground must be sharpened to a point (always at the largest end).

Several kinds of posts are currently available on the market **(Photo 91)**. They last from 10 to 15 years:

- natural wood: chestnut posts, which may be round **(Photo 87)** or split or sawn in half **(Photo 88)** or in quarters; round or sawn locustwood posts **(Photo 89)**, split oak posts (with no sapwood), round larch posts. Natural posts are not treated by impregnation and are therefore not toxic to animals likely to gnaw the wood (except locustwood, which is naturally highly toxic to equines);
- treated wood: milled round pine **(Photo 90)** or spruce. These are brittle woods that must be treated by impregnation (with products that are often toxic to the environment) to ensure durability.



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Quality criteria

Size (Ø and C)

The products on the market have different cross-sections: round stakes in bamboo or wood, wooden stakes or posts sawn or split into two or four with a square or rectangular cross-section. Unlike diameter and circumference classes, which allow stakes of uniform size to be bundled, palletted or packaged, this parameter is rarely mentioned (except for square-section locustwood stakes).

Although there are no standards for classifying stakes, actual practice has imposed various commercial rules.

Diameter (Ø) is used to specify the greatest thickness of a bamboo stake (diameter at the large end, which is driven into the ground) or the width measured at mid-length of a chestnut, larch or treated pine post with a cylindrical or rounded cross-section.

Circumference (C) is a term commonly employed by professionals in the sector to define the perimeter of split or sawn chestnut, locustwood or oak stakes and posts. The circumference of a post is the sum of the widths of all of its sides (perimeter) measured at mid-length **(Photo 86)**.

To suit the demands of market practice, lower and upper size limits have been defined for each product category. Each diameter or circumference limit corresponds to a different class of marketable diameter or circumference size.

A 9-11 cm circumference class means that the company sells uniform batches of stakes with a circumference of 9 cm to 11 cm, thus varying by a margin of 2 cm.

84 - Sawn locustwood stakes have a characteristically uniform cross-section (22 x 22 mm).

85 - Wooden stakes must be straight and well seasoned (85.1). A small amount of sapwood is tolerated, but only on the surface (85.2).

86 - The perimeter of a stake corresponds to the sum of the widths of all of its sides (A+B+C+D).

87 - Pallet of 180 round chestnut stakes (Ø 6-8 cm, L 180 cm).

88 - Pallet of 150 sawn chestnut stakes (C 24-30 cm, L 180 cm).

89 - Pallet of 120 sawn locustwood stakes (Ø 8-10 cm, L 180 cm).

90 - Pallet of round stakes of milled, treated pine (Ø 6-8 cm, L 200 cm).


89


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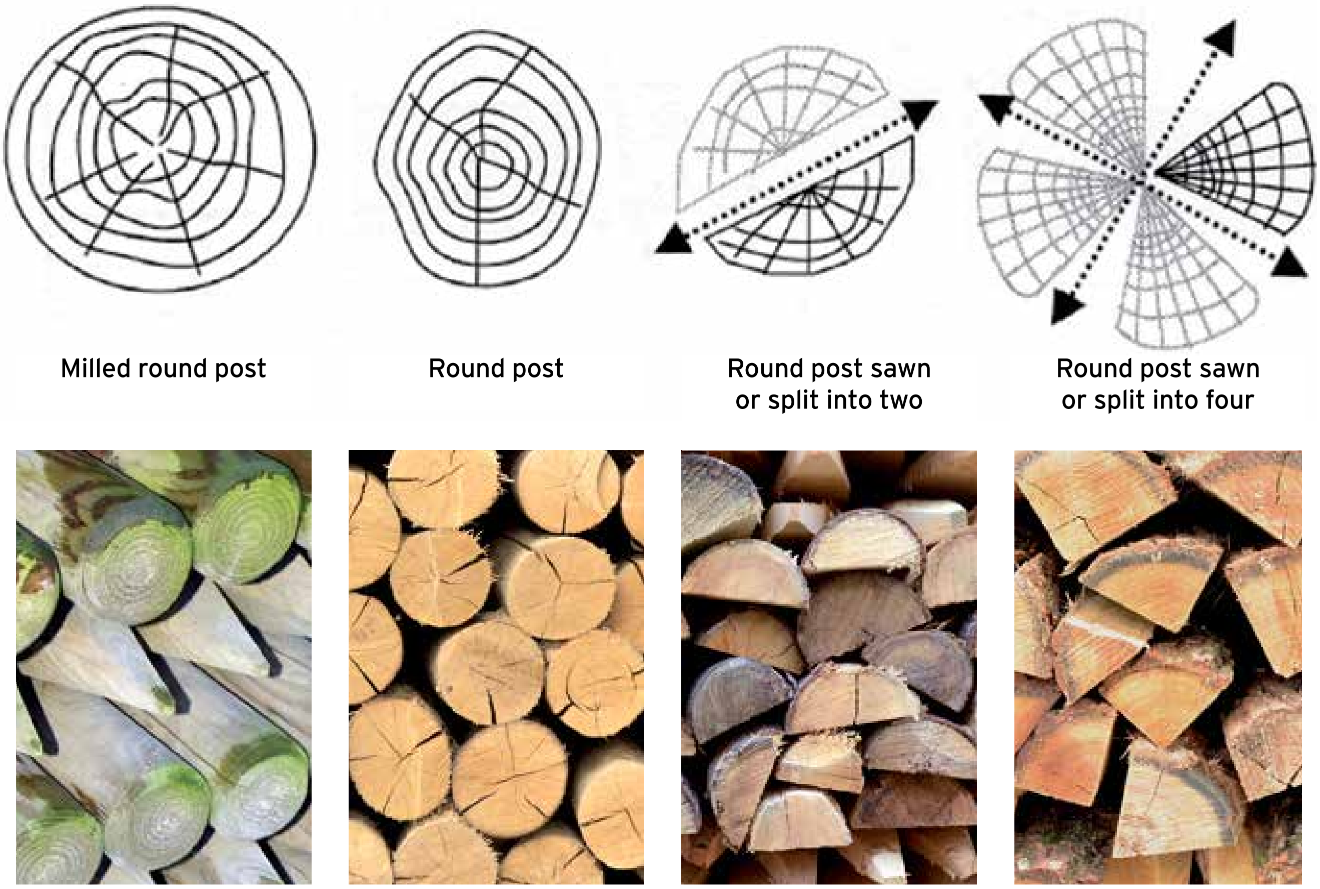


The recommended thickness depends on length:

- bamboo stakes are classified by their diameter at the widest end, in mm (min Ø: 6 mm - max Ø: 16 mm): 6-8 (L 60 or 90 cm), 8-10 (L 90, 120 cm), 10-12 (L 150 cm), 12-14 (L 150, 180 cm), and 16-18 (L 210 cm);
- round, debarked chestnut (more rarely locustwood) posts are classified by their diameter measured at mid-length in cm (min Ø: 3 cm - max Ø: 10 cm): 3-5, 4-6, 6-8, and 8-10 (L 150-160 to 300 cm, every 20-25 cm);
- round, treated pine or spruce or larch posts are classified by their (constant) diameter in cm (min Ø: 5 cm - max Ø: 8 cm): 5 (L 200, 250 cm), 6 (L 200, 250 cm), 7 (L 200, 250, 300 cm), and 8 (L 200, 250, 300 cm);
- split, debarked chestnut stakes are classified by their circumference in cm, measured at mid-length (min C: 9 cm - max C: 22 cm) : 9-11 cm, 11-13 cm, 13-15, 14-16 cm, and 18-22 **(Photo 73)** (L 70-80 to 220 cm, every 20-25 cm). The cross-sections are approximate;
- sawn locustwood stakes are classified by their square cross-section (constant), expressed in mm: 22 x 22 (L 80, 100, 110, 135, 150 cm), 28 x 28 (L 200, 210 cm);
- sawn or split chestnut, locustwood or oak posts are classified by their circumference at mid-length, in mm (min C: 24 cm - max C: 40 cm): 24-30 (L 180 cm), 27-33 (L 200, 250 cm), 30-40 (L 200, 250 cm).

Length (L)

The dimensions of a stake will depend on the height of the tree shelter or fence to be installed and on the substrate into which it will be driven **(Table 8)**. The recommended length of a stake is defined by the height of the tree shelter or individual fence plus the portion of the stake to be driven into the ground.

Stakes with a large cross-section should be chosen to ensure sturdier, more long-lasting protection. They must be driven firmly into the ground, especially in loose soils, to keep them from leaning.

After sub-soiling or disking, or in sandy or gravelly soil, stakes must be driven to the ploughing depth plus an additional 10 cm to 20 cm to keep them from leaning (and to ensure the long-term stability of the tree shelter or fence). A 175 cm stake (recommended length) may therefore need to be driven in to a depth of 40 to 50 cm.

91 - Different cross-sections of wooden posts (from CTBA 2003, modified).

91.1 - Milled round treated pine posts (Ø 6 cm, L 200 cm).

91.2 - Round chestnut posts (Ø 8-10 cm, L 200 cm).

91.3 - ½ round sawn chestnut posts (Ø 9-11 cm, L 180 cm).

91.4 - Sawn locustwood posts (Ø 8-10 cm, L 180 cm).

Choosing stakes for different types of tree guards

Table 8 - Quality criteria and prices (2012/13 season) of supports according to type of tree guard

ANIMAL DAMAGE		CHARACTERISTICS OF THE MESH TREE GUARD			Mesh	RECOMMENDED (or possible) TYPES OF TREE GUARD according to wind conditions and soil (stony, mulched, etc.).	Estimated dealer price (€, excl. VAT)
SPECIES	Maximum height of damage on the tree	Standard height of the tree shelter	Diameter of the tree shelter	Weight range[7]			
Rabbit	< 60 cm	50 cm	Any Ø	Light	All mesh sizes	2 bamboo stakes L 60 cm Ø 6-8 mm	0.06 - 0.08
						1 bamboo stake L 60 cm Ø 6-8 mm + 1 curved metal stake L 70 cm Ø 4 mm[8]	0.18 - 0.21
						2 curved metal stakes L 70 cm Ø 4 mm	0.30 - 0.34
Hare	< 70 cm	60 cm	Any Ø	All weight ranges	All mesh sizes	2 bamboo stakes L 90 cm Ø 6-8 mm	0.10 - 0.12
						1 bamboo stake L 90 cm Ø 6/8 mm + 1 curved metal stake L 80 cm Ø 4 mm[8]	0.22 - 0.25
						2 curved metal stakes L 80 cm Ø 4 mm	0.34 - 0.38
Roe deer	< 150 cm	120 cm	14 - 15 cm	Standard or medium	Fine mesh or double mesh	1 locustwood stake L 150 cm S 22 x 22 mm	0.45 - 0.48
						1 chestnut stake L 150 cm C 9/11 cm	0.47 - 0.53
						1 locustwood stake L 150 cm S 22 x 22 mm + 1 bamboo stake L 120 cm Ø 8/10 mm[8]	0.55 - 0.60
			20 - 30 cm	Standard or medium	Fine mesh or double mesh	1 locustwood stake L 150 cm S 22 x 22 mm	0.45 - 0.48
						1 locustwood stake L 150 cm S 22 x 22 mm + 1 bamboo stake L 150 cm Ø 10/12 mm[8]	0.59 - 0.64
			30 - 33 cm	Medium	Ultra-wide mesh	2 locustwood stakes L 150 cm S 22 x 22 mm	0.90 - 0.96
						2 chestnut stakes L 150 cm C 11-13 cm	1.64 - 2.20
			15 cm	Heavy	Reinforced double mesh	1 locustwood stake L 150 cm S 22 x 22 mm	0.45 - 0.48
						1 chestnut stake L 150 cm C 11-13 cm	0.82 - 1.10
						1 chestnut stake L 150 cm C 18-22 cm	1.57 - 1.80
			20 - 30 cm	Heavy	Reinforced double mesh	1 locustwood stake L 150 cm S 22 x 22 mm	0.45 - 0.48
						1 locustwood stake L 150 cm S 22 x 22 mm + 1 bamboo stake L 150 cm Ø 12-14 mm[8]	0.63 - 0.68
						2 locustwood stakes L 150 cm S 22 x 22 mm	0.90 - 0.96
						1 chestnut stake L 150 cm C 18-22 cm	1.57 - 1.80
		150 cm	14 - 15 cm	All weight ranges	All-mesh	1 locustwood stake L 190 cm S 28 x 28 mm	1.00 - 1.08
						1 chestnut stake L 175 cm C 13-15 cm	1.30 - 1.42
			20 cm	Heavy	Reinforced double mesh	1 locustwood stake L 190 cm S 28 x 28 mm	1.00 - 1.08
						1 chestnut stake L 180 cm C 18-22 cm	1.92 - 2.20
				Ultra-heavy	Wide mesh	1 chestnut stake L 180 cm C 18-22 cm	1.92 - 2.20
						2 locustwood stakes L 190 cm S 28 x 28 mm	2.00 - 2.16
						1 round chestnut post L 180 cm Ø 4-6 cm	3.20 - 3.40
Red deer	< 200 cm	180 cm	20 cm	Medium or heavy	Reinforced double mesh	2 locustwood stakes L 210 cm S 28 x 28 mm	2.20 - 2.38
						2 chestnut stakes L 220 cm C 18-22 cm	2.35 - 2.69
			30 - 33 cm	All weight ranges	All-mesh	2 locustwood stakes L 210 cm S 28 x 28 mm	2.20 - 2.38
						2 round chestnut posts L 250 cm Ø 6-8 cm	2.36 - 2.54
						2 round treated pine posts L 250 cm Ø 5-6 cm	4.80 - 5.20

[7] Mesh weight in grams per m^2 is a realistic criterion for reliable comparisons of different tree shelter models. There are five weight ranges: light (< 150 g/m^2), standard (± 200 - 250 g/m^2), medium (± 250 - 300 g/m^2), heavy (± 400 - 450 g/m^2), and ultra-heavy (> 500 g/m^2).

[8] On windy sites, a bamboo stake is used in addition to a wooden stake to improve the stability and maintain the oval section of a mesh tree guard.

How to install a tree guard

The effectiveness of a mesh tree guard in protecting individual trees from wildlife damage depends not only on careful selection of the tree guard itself and the stakes supporting it, but also on the care taken during installation. Some simple rules need to be followed to install a tree guard properly and to ensure that it does its job until it wears out and has to be removed.

Three essential steps

Three steps are required to protect individual trees from wildlife damage.

Before planting, the forester must choose the right type of protection, i.e., a tree shelter made of a suitable type of UV-treated, high-density polyethylene mesh, or an individual mesh fence to be attached to one or more stakes or wooden posts. The necessary technical specifications will depend on previous identification of the animal species responsible for the damage observed on trees or in neighbouring plant populations. The height, diameter, weight, mesh size, thickness of the mesh wires or strands and the colour of the protective device must be chosen carefully. The type, height, size and number of stakes per plant will depend on the type of protection chosen, the tree species requiring protection and the planting density.

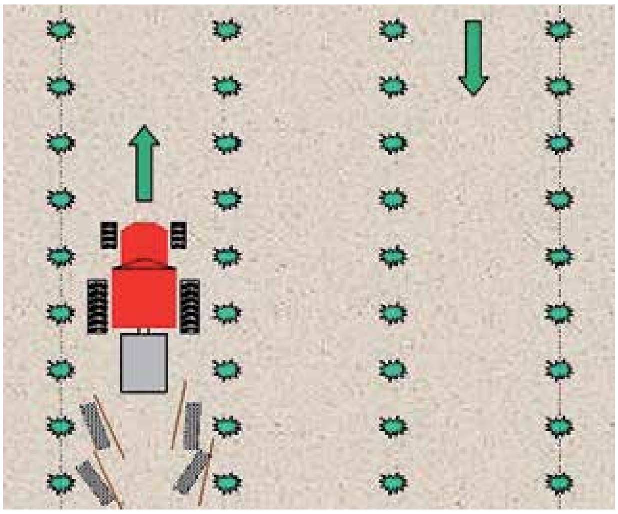
During planting, it is essential to protect the trees on the day they are planted. If the installation of tree shelters or individual fences is postponed, there is an almost immediate risk of animal damage to some of the newly planted trees. Particular care must be taken when positioning the stakes to ensure that they will remain upright (a point which is all too often neglected).

After planting, regular inspections of the trees are essential to check the stability and effectiveness of mesh tree guards or individual wire mesh fences. As soon as plastic mesh becomes worn (or wire mesh comes into close contact with the bark of the tree and liable to become embedded in it), it must be removed.

Installation

Distributing the materials on site

Tree shelters or individual fences must be installed as soon as the young trees are planted. The mesh supplies and stakes can be quickly distributed around the worksite **(Photo 93)** using a farming or forestry tractor and trailer, or a quad bike with a quad-box.



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When planting over a wide area, the supplies can be distributed very efficiently: the tractor or quad driver should skip a row at each turn **(Photo 92)** so as to drive each time between 2 rows of trees where the tree shelters have not yet been installed.
Two people will be needed to distribute the tree shelters and stakes together along each row.

Positioning a mesh tree guard

For rabbits and hares

Placing a lightweight tree guard for rabbits and hares is fast and easy. When installed, the mesh must be under sufficient tension to keep it from sagging.

The recommended procedure is as follows:
- slide the mesh sleeve (L 50 or 60 cm, Ø 14 cm) down around the tree, taking care not to damage the terminal bud;
- insert 2 bamboo stakes (L 60 or 90 cm), one on either side of the tree, driving the large ends (Ø 6-8 or 8-10 mm) deep enough into the ground to ensure they will remain firmly upright;
- make sure the distance between the stakes corresponds to the diameter of the tree shelter (which should be oval); if the operator chooses to install 3 stakes, they should be positioned to form an equilateral triangle;

92 - Route taken by a tractor to distribute tree shelter supplies in an open plantation.

93 - To install a mesh deer guard, you will need a chestnut or locustwood stake (93.1), a lump hammer or sledgehammer, a staple gun (93.2) and staples (93.3). The recommended staple leg length varies from 6 to 10 mm (93.4).
High (≥ 150 cm) wide-meshed (≥ 5 mm) tree guards can be attached to a wooden stake with ties or reusable plastic hose clamps (93.5).

94 - The stake must be driven in at a distance from the tree equal to half the diameter of the tree guard (94.1), so that the tree is at the centre (94.2) and will grow properly inside the mesh.

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95 - Drive the post in straight with a lump hammer or sledgehammer to a sufficient depth to keep it upright.

96 - Press down on the outer folds of a tree guard (that has been delivered flat before installing it) to open it into an oval section.

97 - Pressing on the outer folds places them in a central position, with the centre folds on the outside. The mesh can now be rolled up lengthways.

98 - Rolling a reinforced double-mesh tree guard lengthways before opening it up will help to maintain an oval section.

99 - After pressing and rolling, open up the tree guard to form an oval section (99.1). It is now ready to be placed on the tree. The oval section ensures that the sapling is centred and will grow properly inside the guard.

100 - Slide the mesh sleeve gently down around both tree and wooden stake.

101 - Hold the tree so that its terminal bud will not rub or catch on the mesh.

102 - Starting at the top end, staple the mesh to the wooden stake.

103 - Make sure one of the staples is approximately half way down the mesh.


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104 - Deer guards should be stapled from top to bottom. Some operators prefer to use 5 wire staples 20 cm apart.

105 - It is best to staple along one of the main folds of the mesh to help maintain an oval section.

106 - Never let the mesh extend past the top of the stake, or the wind will cause it to fold over and prevent the leader from growing out of the top of the tree guard.

- position the stakes at a slight angle so as to stretch the mesh slightly and thus reduce the risk of wind damage;
- to maintain the oval section of the tree guard (when delivered flat), position it so that the folds are perpendicular to the ground between the stakes;
- make sure that the base of the tree guard is in close contact with the ground.

For roe deer

The stake (sawn, pointed locustwood stake, L 150 cm - S 22 x 22 mm or split, pointed chestnut stake L 150 cm - C 18-22 cm) **(Photo 93.1)** must be driven in straight **(Photo 95)** to a depth of 30 cm to prevent it from leaning, and even deeper if the soil is gravelly or was ploughed with a subsoiler.

In windy areas, a (split) bamboo stake can be placed opposite the wooden stake to stop the wind from shifting a light- or standard-weight tree guard.

When positioning the stake, the following must be checked:

- diameter of the tree guard (Ø 14-15 to 20 cm): the distance from the stake to the tree must be equal to half the diameter of the tree guard (on average 7 cm for a deer guard protecting a broadleaved tree) to ensure that the sapling is centred and will grow properly inside the tube **(Photo 94)**;
- prevailing wind direction: the stake should be placed face to the wind, in front of the sapling, so that the wind will not twist the flexible mesh around the stakes. This is a common problem with light- or standard-weight mesh. It can harm the plant by twisting the stem or snapping its branches, and interfere with the height growth of the leader;
- slope of the planting site: the stake should be placed on the uphill side of the tree and driven in 10 to 20 cm deeper than usual, depending on the angle of the slope;
- the pre-folded (2-4 folds) mesh should be pressed by hand

Installing a mesh deer guard

Tree guards to protect trees from roe-deer damage are more complicated to install than rabbit and hare guards (cf. p. 52).

Work in three stages, observing several technical rules to ensure long-term stability and effectiveness:

- drive the stakes in close to the tree;
- slide the mesh very gently down the tree;
- fasten the mesh firmly to the supporting stake.


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to form an oval section **(Photo 96)** so that it will slip easily over the plant. This is done by pressing on the outer folds of mesh guards that have been delivered flat **(Photo 97)**. Reinforced double mesh tree guards may also need to be rolled lengthways **(Photo 98)** to help maintain an oval section **(Photo 99)** once they are opened and installed;

- slide the mesh down around both plant and wooden stake **(Photo 100)**. This must be done gently **(Photo 101)** so as not to damage the terminal and lateral buds by rubbing or tearing. To keep rodents out, always make sure that the base of the tree guard is in close contact with the ground;
- staple the mesh to the stake with three wide, 10-mm or 12-mm staples placed at an equal distance along the height of the tree guard (in the middle and at each end) **(Photo 102, Photo 103 and Photo 104)**. Position the tree guard so that one of its folds is in contact with the stake. Stapling along one of the outer (main) folds will help to keep the tree guard open **(Photo 105)**;
- never let the mesh extend past the top of the stake, or the wind may cause it to fold over and stop the leader from growing out of the top **(Photo 106)**. If necessary, fold the top end over like a sock so that it is level with the top of the stake. This is essential with lightweight, standard and some mixed-mesh tree guards, and may even be needed for heavy, reinforced and more rigid guards.

The stability of mesh guards around saplings in an agroforestry plantation can be improved by attaching them to 2 wooden stakes with fence ties or reusable plastic hose clamps **(Photo 93.5)**.

For red deer

Mesh tree guards against red deer damage are usually fixed to sawn pointed square-section chestnut stakes (L 210 cm, S 28 x 28 mm). If the density is high, we strongly recommend using 2 round chestnut or treated pine posts (L 250 cm - Ø 4-6 cm, or better 6/8 cm) to support a heavyweight mixed reinforced mesh tree guard (ht 180 cm, Ø 20 cm, or better 30 cm). Avoid ultra-wide mesh guards.

The trickiest phase when installing a mesh tree guard for protection against red deer damage is the positioning of the wooden stakes:

- the stakes must be equidistant from either side of the plant **(Photo 108)**. The distance between them will correspond to the diameter of the tree guard;
- using a crowbar, make starter holes (at least as deep as a quarter of the length of the wooden posts) to ensure better long-term stability. A simpler method would be to drive the posts directly into the ground, but there is a much greater risk of damaging the wood and this is the least reliable method of installation;
- drive each post into its starter hole to a depth of 40 to 50 cm. A high (ht 180 cm) wide-diameter (20-30 cm) mesh tree guard is placed by sliding it gently down around the tree and the wooden supports;
- attach the tree guard to its wooden support with fence staples 20 to 30 cm apart.

107 - Round pointed chestnut posts (L 250 cm, Ø 6-8 cm).

108 - The distance between the wooden posts will correspond to the diameter of the tree guard. This ensures unobstructed growth of the sapling inside the mesh guard until it emerges from the top.

Checking the trees

Regular maintenance

It would be a mistake to think that mesh tree guards will last for a long time without any maintenance.

After planting, owners or plantation maintenance or management contractors are strongly advised to make regular site inspections in order to straighten, repair or replace tree guards damaged by animals or high winds. In the event of vandalism (theft or wanton destruction), the tree guards and their supports should be quickly replaced.

During the winter following the first growing season, all the stakes should be reinforced (average work time: 100 to 110 stakes per hour). In sites ploughed with a subsoiler, stakes will often sink by a further 10 to 15 cm. Stapling should also be reinforced at the same time, if necessary.

When checking wide-mesh tree guards, any leader shoots that have grown out through the mesh should be (gently) pushed back. To avoid this problem, it is advisable to restrict this type of mesh to conifer and tall deciduous saplings (stems > 150 cm).

With beeches protected by fine-meshed tree guards, the spring shoots, which always bend downwards, cannot straighten out if the guard is too narrow. This results in unacceptable malformation of the trunk unless the site is checked at least twice a year (in late spring and in the summer) and the problem corrected **(Photo 62)**. An alternative solution is to use saplings that are nearly as tall as their tree guard (or better still, to use tree guards at least 20 cm in diameter that are attached to 2 stakes to keep them wide open.

The top edges of heavyweight reinforced double-mesh tree guards can be abrasive **(Photo 109.1)** and should be folded over, like a sock **(Photo 109.2)**, or slit around the top **(Photo 109.3)**, to prevent damage to trees with thin bark in windy sites especially.

Anticipating health problems

Some health problems affecting young trees are directly attributable to mesh tree guards. Two potential problems are overheating of the trunks and creating shelter for wood-eating insects.

The trunks of thin-barked species, such as beech, cherry, maple and especially poplars, are particularly susceptible to overheating when the plastic mesh is too tight.


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High temperatures and exposure to sunlight will promote bark lesions inside the mesh guard **(Photo 110)**, which consistently develop on the southwest side. Black plastic mesh will cause the most severe damage.

3 to 8 year-old plantings seem to be the most affected. Symptoms are peeling bark and calluses forming around the lesions. The wood becomes exposed and these fragile areas may be colonised by wood-rotting fungi **(Photo 111)**.

In poplar groves, wood-eating insects, especially longhorn beetles (*Saperda carcharias*) and goat moths (*Cossus cossus*), may lay their eggs inside the tree guard, where they are protected from predators. These insects are especially attracted to trunks when there is little space between them and the mesh.

The damage caused by these wood-eating insects may not be very serious, unless a woodpecker spots the larvae and then pecks large holes in the wood to get at them **(Photo 112)**. Occasionally, tree guards may also become a refuge for rodents. They can also create a microclimate favourable to the development of aphids (e.g., black cherry aphid, woolly poplar aphid).

Mesh tree guards must be removed when they become tight against the trunks because the risk of overheating is greatest at this point **(Photo 113)**. If they are not removed in time, the stake to which the mesh is attached can become embedded in the trunk **(Photo 114)**.

Removinge worn tree guards

Banned disposal methods

Foresters or farmers who have used mesh tree guards, plastic mulch, fertiliser bags or plant containers might be tempted to abandon them on the plantation. They may decide to stockpile these worn materials in the corner of a field to burn or bury them at a later stage.

109 - The edges of heavy reinforced double-mesh tree shelters are potentially abrasive (Photo 109.1) and should be folded over like a sock (109.2) or slit around the top (109.3) to prevent damage to species with thin bark.

110 - In thin-barked tree species such as wild cherry (110.1) and poplar (110.2), high temperatures and sunlight on plastic mesh tree guards that are in close contact with the trunks will promote bark lesions.

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111 - Bark peeling caused by overheating of the trunk and colonisation of the exposed wood by wood-rotting fungi.

112 - The holes in this "Beaupré" poplar were made by a woodpecker to get at the wood-eating insects colonising the tree.

113 - Heavyweight reinforced mesh tree guards may need to be removed when they become tight against the trunks.

114 - The wooden stake embedded in the lower part of the trunk (114.1) will reduce the technological quality of the butt log (114.2).

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Abandoning, burying, stockpiling and illegal burning of plastics are polluting and dangerous for the environment, and strictly forbidden by French law (Forest Code, Environment Code and local by-laws).

Abandoned plastic sheets pollute the environment visually, float on the surface of lakes and rivers, obstruct gratings, canals and ditches and can be deadly when ingested by animals. Stockpiling in a corner of a forest plot or elsewhere can be considered as fly tipping and may therefore be illegal under local regulations.

Open-air burning can pollute the air (because the various materials burning in the bonfire can produce noxious smoke), create wildfire risks and cause burns to people (falls and flare-ups) as well as damaging soil fauna and flora.

Buried plastics break down much more slowly than the plant materials. The plastic fragments degrade soil quality and prevent, water and micro-organisms from circulating freely.

To maintain the health and vitality of forest ecosystems, worn plastic mesh tree guards **(photo 115)** must be recovered and transported to a recycling facility when they no longer provide trees with any protection **(Tip 8)**.

How to dispose of plastic waste?

Worn mesh tree guards are removed when the trees are large enough to resist animal damage.

If a worn plastic tree guard is tight against the bark, an operator using an inappropriate method to remove it may injure the tree.

Cutting off the plastic mesh with a standard boxcutter blade can injure the bark and the wood beneath. We recommend using a carpet knife, as the large hooked blade with rounded edges avoids damage to wood tissues, while the sharp tip easily cuts through the plastic mesh.

115 - Deteriorated plastic mesh tree guards must be removed when the trees no longer need protection.

116 - Careless removal of worn tree guards with a knife can injure the bark and the wood beneath it.

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Tip 8 - Disposal of plastic waste without polluting the environment: what French law says

At the end of their useful life, worn plastic mesh tree guards become "waste". By definition, waste is a product disposed of, or to be disposed of, by its owner.

There are no specific regulations for plastic waste, which must be disposed of, like any other waste, in accordance with statutory rules and in compliance with the Environment Code in particular.

This stipulates that any person producing waste must dispose of it without endangering human health or harming the environment, and in particular without causing risks to water, soils, flora and fauna, without causing offensive smells or noise pollution and without damaging sites or landscapes (Art. L541-1).

Any person who produces or owns waste (Art. L541-2) is:

- required to arrange for its collection and transport for recycling or disposal;
- responsible for the management of their waste up to its disposal or final recovery, even when the waste is transferred to a third party for processing.

All foresters, farmers, plant nurseries, horticultural operators and fruit-growers, local councils, other local authorities and private companies using plastic materials (such as motorway and railway operators) are considered as producers or owners of plastic waste and are responsible for its disposal.

By participating in the recovery of plastic waste, they are complying with the law and contributing to the constant effort to reduce the large amount of plastic mesh waste abandoned in the environment (estimated at an average of 220 to 240 tonnes per year in France[9]).

(9) Some 1.8 to 1.85 million mesh rabbit and hare guards and 1.2 to 1.25 million mesh deer guards are sold every year in France to protect forestry and landscape plantations. The average weight of rabbit (or hare) and deer guards is 40 and 130 grams per unit respectively.

Recycling plastic mesh tree guards

Although worn plastic mesh tree shelters are fully recyclable, only a small proportion is recycled at present.

Foresters and farmers are responsible for the disposal of their waste, but numerous technical, economical and environmental restrictions can prompt illegal disposal.

For many years, disposal in landfills was an easy and legal solution, but this is now banned. Since 1st July 2002, non-hazardous waste disposal facilities can accept only final non-recyclable waste, and worn tree guards do not come into this category.

The main problem for any owner or producer of plastic waste is to identify a waste recovery operator able to provide local waste collection services.

Plastics manufacturers are gradually becoming organised to address this problem. One manufacturer of mesh tree guards has implemented a Europe-wide environmental quality charter for recovering and recycling their products.

Plastic waste must be delivered by users to collection points managed by distributors who have signed up to the charter.

In conclusion

Glossary

ANTLERS Large, branched, bony appendages on the heads of most deer species.

BARK Outermost protective layer of a tree trunk, branch, twig or root. Bark refers to all tissue located outside the cambium. The inner layer of bark in contact with the cambium is formed of living tissue (phloem), while the thickest layer, in contact with the outside, is made up of dead tissue (cork).

BEAM Central shaft of red deer, roe deer, or fallow deer antlers. Antlers comprise a central shaft (beam) and smaller branches (tines or points).

BOLE Portion of a tree between the stump and crown.

BIODEGRADATION Degradation of dead organic matter by biochemical consumption or transformation by soil organisms: micro-organisms, fungi, saprophytes, arthropods, worms, etc.

BIODIVERSITY All of the different living species present in an environment.

BIOTOPE Localised space or geographic area of varying dimensions; a biological environment possessing relatively stable ecological features necessary to the existence of a specific assemblage of plants and animals, for which it constitutes the normal habitat (often used synonymously with "habitat" in English).

BROWSING Act of feeding on the young shoots of a tree (or shrub) by wild or domestic animals.

BUDBREAK Plant growth stage corresponding to the resumption of growth in trees (when buds open and elongate).

BUSH Woody plant with a stem branching from the base, usually less than 7 metres in height when adult (e.g. Scotch broom, hazel).

CAMBIUM Continuous layer of actively dividing cells located between the wood and the phloem (bark), which is responsible for growth in the diameter of roots, trunks, branches and twigs.

CANKER Irregular outgrowth on a tree trunk or tumour caused by a fungal parasite.

CERVIDAE Family of even-toed ruminant mammals (red deer, roe deer, fallow deer). The males have branched antlers on their heads that are usually shed each year.

CLEARING Forest management operation to control competing vegetation and to balance the proportions of tree species in young forest stands less than 3 metres in height.

COLLAR Boundary between the stem and the roots of a plant.

CROWN Portion of a tree from the lowest branch to the top.

DAMAGE The result of an act by wild or domestic animals, due to their presence, feeding, and/or behaviour, which reduces the quantity or quality of the current or future yield of a timber or agricultural crop.

DEER RUB An area of peeling, fraying or smoothed bark on the stems of young broadleaved trees or conifers, mainly caused by friction when deer rub off their velvet against a tree.

DENSITY Number of individuals of a given wildlife species in an identified area, expressed in number of animals per hundred hectares.

DESIRED TREE Tree identified within a stand for features with potential to meet a particular objective in the longer term. Silvicultural operations in the stand are then geared to favour its development.

ECOSYSTEM A community formed by two interacting components: the biotope, defined by the prevailing site conditions in a homogeneous area, and the biota, which includes all living beings found in that area. An ecosystem also includes the functional relationships that living organisms have with each other and with the environment.

EDGE Border or extreme limit of a forest or woodland (synonym: margin).

FAUNA Collective term for all wild and domestic animals living free or in captivity in a specific region, environment or period of time.

FOREST TREE SEEDLING a) In a nursery, a young woody plant grown from seed, not transplanted. b) In forestry, a young stem growing from seed and less than 0.50 m in height.

GAME Any animal hunted in a given area for its meat or for other purposes.

GIRDLING Total stripping of bark all round a root, stem, branch or tree.

IN RUT Physiological state of arousal in animals, especially certain mammals, which drives them to mate.

LEPORIDAE Family of long-eared mammals including rabbits and hares.

LIGNEOUS Woody, having the nature or consistency of wood.

LIGNIN Complex organic compound present in wood (15 % to 35 %), rendering it rigid, less permeable to moisture and therefore more resistant to decomposition.

LIVESTOCK Any type of animal that has adapted to life in close association with humans from having been raised in captivity on farms, but generally excluding poultry, rabbits, pets, etc.

LOWER TRUNK Portion of a tree trunk located between the stump and the first branches of the crown.

MAMMAL Warm-blooded, live-bearing vertebrate animal with lungs, the females of which feed their young with milk from their mammary glands.

PALATABLE The unique sensory quality of a plant or other food that attracts an animal because it is likely to satisfy its bodily needs.

POLE-SIZED TREES Young trees 10 to 25 cm in diameter in a young forest stand.

RACK The beam and antlers of a deer.

RAMIAL CHIPPED WOOD Name given to non-composted wood chips from the small branches (maximum 7 cm in diameter) of hardwoods.

ROT Disease caused by certain parasitic fungi that decomposes the wood of many woody plant species (vines, fruit trees, ornamental and forest trees and shrubs).

RUMEN First division of the stomach in ruminants, in which in which most food collects after being swallowed and from which it is later regurgitated as cud.

RUMINANT Two-toed ungulate mammal capable of regurgitating and chewing (ruminating) its food after it has been partially digested in part of its stomach (the rumen).

RUTTING SEASON Mating season of ruminant animals.

SAP Liquid circulating in the different plant organs. Xylem sap, which is rich in minerals, rises from the roots to the leaves. Phloem sap, which is rich in organic nutrients, is produced by the leaves and is redistributed to all plant organs.

SAPWOOD Living tissue of a tree located directly under the bark and corresponding to the growth zones. It is tender and generally whitish.

STAKE Length of wood used to support a tree, shrub or vine during its first few years of growth.

STEMWOOD The wood of trunks or large branches (> 7 cm in diameter.

STRAW Cylindrical, hollow stems of grasses with nodes, but rarely branches. Portion of the stems of cereal crops left standing after harvest.

(BARK) STRIPPING Result of bark consumption a species of ungulate (red deer, roe deer, fallow deer, etc.).

SUBERISATION Transformation into cork of certain aging tissues, whose cell walls become impregnated with suberin, a highly impermeable lipid that helps insulate the plant from the outside environment.

TINE A branch that develops on the antlers of red deer, roe deer and fallow deer. Their number generally increases by one each summer, when the antlers re-grow, which can help to determine the age of the animal. Also called "points".

TREE Woody plant with a single stem, without basal lateral branches, comprising a trunk and a crown and reaching over 7 meters in height when adult.

TREE COVER Area occupied horizontally by the crown of a tree, a population of trees, a forest stand as a whole (total cover) or one or more layers of vegetation (partial cover).

TWIG Small thin branch of a woody plant.

VELVET Thin, vascularised, velvety skin covered with fine hairs, which completely covers and protects deer antlers as they develop and grow. It dries out once the antlers have acquired their natural hardness.

VELVET SCRAPING Male deer rub their antlers against the stem or trunk of a tree to rid them of the velvet as it starts to peel off.

117 - A wild cherry planted among field beans sown under a cover crop of oats. The heavyweight (400 g/m^2) reinforced double-mesh tree guard (ht 120 cm, Ø 15 cm) is designed to protect trees against roe deer damage.

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Protecting trees from wildlife damage

Mesh tree guards

Many forested and agricultural areas are experiencing wildlife population explosions. Wildlife most certainly has a legitimate and necessary place in the ecosystem, but the biological equilibrium of forests and fields is increasingly threatened by the demographic and geographic expansion of populations of certain animal species.

There is no magic recipe for reconciling efficient forestry with the presence of wildlife in forests and fields. Instead, we have a series of more or less partial measures that have to be adapted as well as possible to each individual situation.

Looking beyond today's fierce controversies over the balance between forests, farmlands and wildlife, this technical guide sets out to review current knowledge on damage to trees caused by certain wild animals (rabbits, hares, roe deer and red deer) and to provide a detailed description of one of the main methods currently in use to protect individual trees directly from animal damage, i.e. mesh tree shelters.

The guide describes all the possible types of damage to trees caused by these animals and criteria for identifying the in the field. The aim is to help foresters to correctly identify the animal responsible for the damage and therefore to choose the best type of protection.

The wide range of products on the market requires foresters and agroforestry managers to understand their different technical properties and quality criteria so that they can choose the type of tree shelter that best meets their needs.

The effectiveness of mesh tree shelters essentially depends on their durability and resistance to wind, and on the techniques used to install them. The guide provides clear illustrations of the different types of mesh tree shelters and stakes, with recommendations on their quality.

This is a technical guide designed to help aspiring foresters to minimize the costs of protecting their future plantations and naturally regenerating forests from potential damage by wildlife. We advise (agro)foresters wanting to protect their trees to read about the solutions proposed here before putting them into practice.

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