# A Study of the Impact of the European Wild Rabbit (*Oryctolagus cuniculus L.*), on Young Tree Plantations

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## Summary

The relative susceptibility of seven tree species of both broadleaves and conifers, to damage by the European rabbit, (*Oryctolagus cuniculus L.*), was investigated on two newly planted sites in Co. Wicklow. The incidence and the severity of three different forms of rabbit damage were assessed using the nearest neighbour sampling technique. Four tree species were identified as being susceptible to all forms of rabbit damage that is, either to the leading shoot, to side-shoots or to the stem. These were; penduculate oak (*Quercus robur L.*), ash (*Fraxinus excelsior L.*), Sitka spruce (*Picea sitchensis (Bong.) Carr*) and Japanese larch (*Larix kaempferi L.*). Those that displayed relatively low levels of damage were beech (*Fagus sylvatica L.*), sweet chestnut (*Castanea sativa L.*), and Douglas fir (*Pseudotsuga menziesii L.*). Damage to the side-shoots of all of the young trees was found to be consistently high for all four vulnerable species. Most of the damage was slight but severe side-shoot damage did occur in ash. The incidence of leader loss was found to be high for two species, oak and ash. The incidence and severity of bole damage was most prevalent in ash.

Differences between tree species in susceptibility to different forms of rabbit damage were identified as being due to a number of interrelated factors, which were ecological, chemical and physical in nature.

## Introduction

The rabbit is primarily a grazing mammal and is associated with a wide variety of habitat types (Anon.,1982; Gibb,1990). It can cause serious and sometimes devastating damage to forests (Gill,1992) and this is most prevalent in young plantations, up to eight years following planting (Springthorpe and Myhill, 1985). Changes in the Common Agricultural Policy and the large increase in private planting in recent years (O'Brien, 1990) have resulted in an increase in the range of site types becoming available for forestry in Ireland. As an increasing proportion of these sites have free draining soils, this may have accentuated the concern about rabbits as pests.

Rabbit densities have not been documented in any detail to date in Ireland (E. Grennan,Wildlife Service, personal communication), although anecdotal evidence from various sources countrywide point to an increase in the population density of the rabbit, albeit lower than that currently experienced in England (Ross and Sanders, 1987; Lloyd, 1970). It is unclear as to whether a reduction in virulence of the Myxoma virus as reported in England (Trout, Tapper and Harradine, 1986), has substantially affected the population levels in this country but this a distinct possibility. Young forest plantations are preferred habitats for rabbits. A survey of 173 forests in 1985 showed that rabbits were present in 93% of these areas with damage being reported in 42% (Hannan, 1986). Actual damage to trees was confined to the youngest plantations. Severe damage, (characterised by 20% or more of trees suffering damage), constituted a sizeable proportion.

Rabbits damage trees in two ways: by browsing (that is by nibbling shoots and buds) or by stripping the bark (Anon., 1982; Springthorpe and Myhill, 1985). Browsing young trees is by far the most serious form of damage and its incidence is highest in winter and in spring (Hannan, 1986). The selectivity of rabbits, demonstrated by their tendency to drop damaged shoots, is thought to be related to their role as grazers (Gill, 1992). In general, the effects on the subsequent growth and development of trees as a direct result of rabbit browsing are not known (Ratcliffe, 1989), although in some cases, multiple leaders may develop (Staines and Welsh, 1984), thereby reducing the value of trees destined for structural timber. The inherent capacity for trees to recover following injury has not been examined in great detail (Burdekin and Radcliffe, 1985), although saplings of many broadleaved species have demonstrated their capacity to sprout repeatedly after being pruned back by browsing (Miles and Kinnaird, 1979). In addition to this, it is known that certain species, such as Sitka spruce can withstand a greater degree of leader browsing than either Douglas fir, Japanese larch or any of the broadleaves (Melville, Tee and Rennolls, 1983).

Work on Norway spruce (*Picea abies*) has shown that heavy browsing of lateral branches in one year, leaving the leading shoot intact, significantly reduced the rate of vertical growth over the following eight years (Pepper and Hewison, 1989). On the other hand, for young pine seedlings (*Pinus radiata*) in Tasmania, economic loss was demonstrated only in the case of very severe browsing to the leading shoot (Nielsen, 1981).

Unpublished data compiled by the Forestry Commission has indicated that almost any species of tree may be damaged by rabbits, especially where the number of rabbits is high (Gill, 1992). Craig (1871) was the first author to record browsing preferences by rabbits. However, little work has been carried out in this area to date and information on browsing preferences is generally poor. Craig showed that both rabbits and hares preferred oak species, larch, spruce and Scots pine to birch. Plant secondary substances in the bark of birch plays an important role in this preference by hares, nutrient conditions will influence the choice (Votila, I., J. Tahvaninan and M. Taavitsainin, 1993). There is little information on the role of plant secondary metabolites as natural feeding deterrents for rabbits, as opposed to hares (Ianson and Palo, 1991;). Later in 1946, Allman gave anecdotal evidence for browsing by hares of Corsican pine (*Pinus nigra*) in preference to Lodgepole pine (*Pinus contorta*) or to Scots pine (*Pinus sylvestris*) (Allman, 1946).

It is against this background that this study was carried out. The main objectives of the study were:

1. To evaluate the relative susceptibility of seven different tree species to browsing damage by rabbits.
2. To determine the extent and severity of the different forms of damage identified for the seven tree species.

**Materials and Methods**

The field work was carried out on two sites in County Wicklow during the period October to December 1992. Both sites were within 15 km of the coast, and at moderate elevations but differed in layout and species composition. Site one is at Kilpoole, at 90m above sea level and was planted in March/April 1992 with common ash (1.6ha) and Sitka spruce (2.4ha). Site two, situated at Carrigmore and Ballinclare, near to Glenealy village is 80-90m above sea level and consists of 16ha of mixed broadleaves and conifers, also planted in 1992. Seven tree species were examined for evidence of rabbit damage; oak (*Quercus robur L.*), ash (*Fraxinus excelsior L.*), beech (*Fagus sylvatica L.*), sweet chestnut (*Castanea sativa L.*), Sitka spruce (*Picea sitchensis (Bong.) Carr*)., Douglas fir (*Pseudotsuga menziesii L.*) and Japanese larch (*Larix kaempferi L.*). Rabbit damage to ash and Sitka spruce was studied on site one and the damage to the other five species was studied on site two. Approximately half of the oak trees and all of the ash trees on site two had tree shelters, 45 cm in height. The presence of tree shelters on ash trees on site two prohibited any contrast of results for ash on both sites. Approximately half of the oak and all of the ash on site two were protected by tree shelters, 45 cm in height. However, these shelters were not erected until two months after planting. Therefore, upon examination of the trees in October it was concluded that all of the damage occurred in May/June 1992 and that the shelters provided adequate protection against subsequent attack. Damage that occurred before erection was assessed.

Damage was quantified using the nearest neighbour survey method (Melville *et al.,* 1983). This involved the systemic selection of a number of points throughout each species plot. At each of these points a

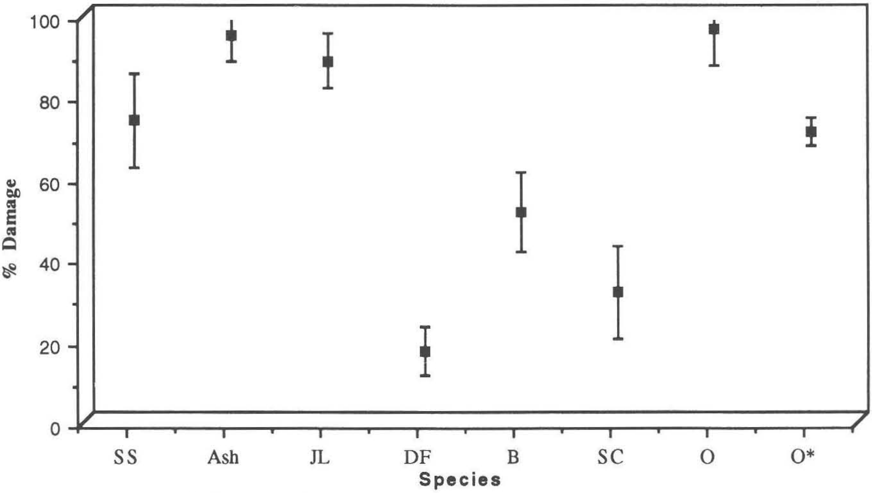


**Figure 1.** Percentage damage for the seven species examined in the two study areas. (Vertical bars represent 95% confidence limits of the estimates.)

predetermined number of trees was examined for damage. The trees which formed a cluster were chosen objectively and independently of any damage. In this study the sampling cluster size was chosen to be six and thus for an accuracy of 10% at the 95% confidence level, it was necessary to sample at least 100 trees. Sampling points were spaced systematically throughout the plot and reached simply by walking the required distance D. This distance was calculated after Melville *et al.*, (1983) as follows:

$$D = \frac{\sqrt{A \times 10{,}000}}{n}$$

where D = the distance between points (metres)
A = the area of the plot (hectares)
n = the number of points allotted.

Thus, the distance between clusters was the only between plot variable and this was directly proportional to the plot size under investigation. The larger the area being assessed, the greater the distance between clusters. All of the plots were sampled in proportion to their size.

Each tree within the cluster was examined for damage and the tree height recorded. If damaged, the tree was further inspected for the type and severity of damage. The categories of damage into which the

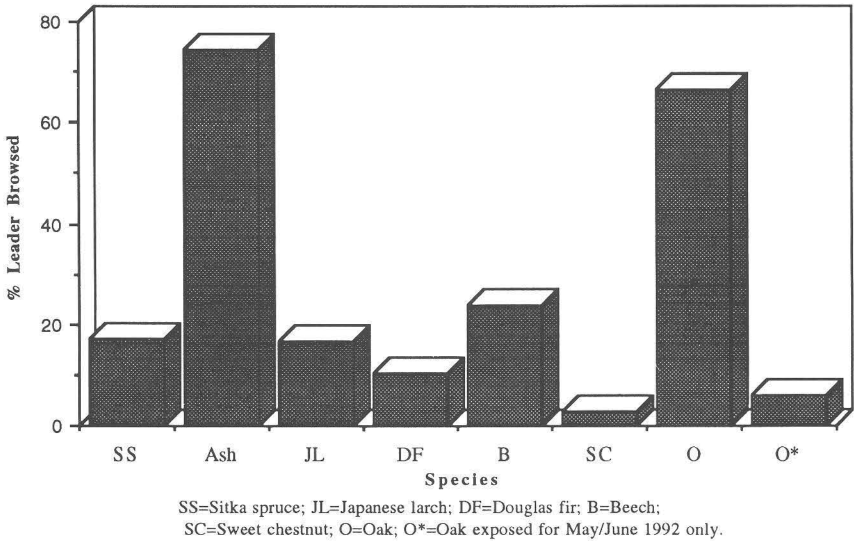


**Figure 2.** The percentage damage to the leading shoot for the seven species examined in the two study areas.

trees were grouped were not mutually exclusive and were as follows: 1) leader browsed, 2) side-shoot browsed and 3) bark stripped. The severity of damage was then visually assessed and classified as either slight (0-30% removed), moderate (31-60% removed) or severe (61-100% removed).

As vulnerability to browsing damage is related to the amount of other browse available (Kinnaird, 1974; Miles and Kinnaird, 1979; Springthorpe and Myhill, 1985), the presence or absence of herbicide immediately surrounding each tree was recorded. The presence of tree shelters and shoots on the ground beside the damaged tree was also noted. For each cluster, the vegetation cover within the vicinity that is, within $10m^2$ of the centre point of the tree cluster was assessed as being either low (less than 10cm in height), medium (10-25cm in height), or high (greater than 25 cm in height), and the dominant plant species present were noted also.

Rabbit population numbers are difficult to estimate to any degree of accuracy (Kolb, 1985). The density of pellets per hectare has been used to estimate the population of rabbits in a warren (Leach, 1989). Maximum breeding populations have been estimated at 13 individuals per hectare (Lockley, 1964). However this is complicated by the fact that pellets can be left anywhere within the range of the rabbit [100m (Cowan, Hardy, Vaughan and Christie, 1989) to 500m from the burrow (Gibb, 1990)], or concentrated in latrines on the boundaries of its territory (Leach, 1989). An alternative method for gaining an index of the population was investigated by Kolb. This involved utilising the number of burrow entrance holes but was also found to be unreliable, due to the variability in the number of entrance holes relative to other features. The number of scrapes per unit area may be a useful aid in gaining an index of population in young plantations due to the availability of edible roots near to the surface (Downes, 1993) but this is a function of the quality and availability of other preferred plant species. Clearly, the practice of applying herbicide around each tree would encourage scraping and indeed browsing.

A rough index of the rabbit population density on each tree species plot was determined by systematic plot sampling of rabbit pellets and scrapes, based at each sampling point for tree damage. The number of pellets in a plot of $10m^2$, centred on the tree cluster sampling unit was counted. A count of one to 20 pellets or less than two scrapes constituted low rabbit activity, while 21 to 40 pellets (two to four scrapes) and 41 to 60 pellets (five to eight scrapes) were deemed to show medium and high rabbit activity respectively. Very high rabbit activity was shown by a pellet count of greater than 60, or more than eight scrapes, and distinguished from high rabbit activity by the presence of burrows and forms on the site itself (Harting, 1986). This systematic sampling was considered to be reasonably accurate for the relatively small areas under investigation in this study.

## Results

A total of 828 young trees were sampled in this study of browsing damage by rabbits. The percentage mortality was approximately 3% for species such as ash, Sitka spruce and beech and no mortality was recorded for all other tree species studied. Mortality was unrelated to browsing damage. Mean tree height for damaged and undamaged trees, as well as their percentage reduction in height (measured during the assessment in October 1992) are shown in Table 1. Oak, ash and Douglas fir all displayed a relatively large reduction in height (30%), while for sweet chestnut and "sheltered" oak the reduction in height was just 3% (Table 1). The proportion of young trees which suffered from any form of rabbit damage is shown in Figure 1. The four most vulnerable tree species were oak, ash, Japanese larch and Sitka spruce. The accuracy of estimates of is shown by the vertical error bars, the percentage damage levels lie within these ranges. Beech, sweet chestnut and Douglas fir all displayed relatively low levels of damage. Douglas fir was the least susceptible to any form of rabbit damage, with an incidence of just 16.7%. Leader loss was of economic significance for two species, ash and oak (Figure 2). The trend for total overall damage was similar to that of side-shoot damage (Figure 3), although we see a different pattern emerged for stem damage (Figure 4).

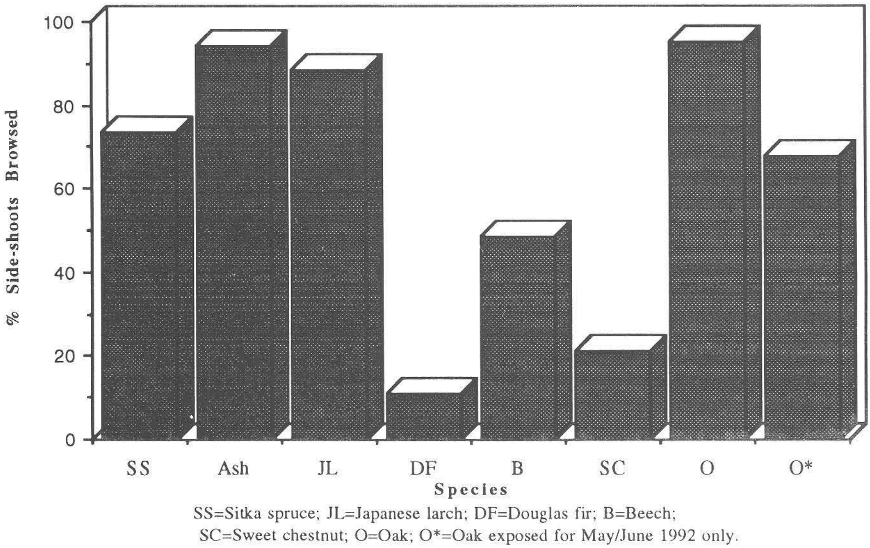


**Figure 3.** The percentage damage to side shoots for the seven different species in the two study areas.

**Table 1:** Mean values for undamaged and damaged tree heights, in cm and the percentage reduction in height, for seven tree species examined in the two study sites.

| Species | Mean undamaged tree height (cm) | Mean damaged tree height (cm) | Mean reduction in tree height (%) |
|---|---|---|---|
| Sitka Spruce | 55.2 | 42.5 | 23.0 |
| Ash | 51.3 | 34.9 | 32.0 |
| Japanese Larch | 80.4 | 68.0 | 15.5 |
| Douglas Fir | 0.5 | 41.1 | 32.7 |
| Beech | 57.2 | 49.6 | 13.3 |
| Sweet Chestnut | 92.3 | 89.6 | 2.9 |
| Penduncluate Oak | 66.0 | 63.7 | 3.4 |
| Penduncluate Oak* | 66.0 | 40.9 | 38.1 |

The tree species which suffered the highest level of leader loss were ash and oak, at 74.3% and 66.7% respectively (Figure 2). Levels of damage were less than 20% for the other five species, with Douglas fir proving to be

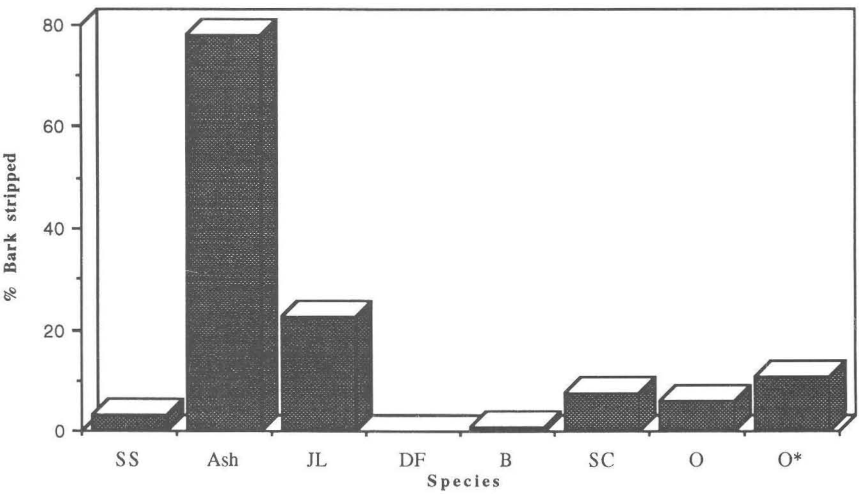


**Figure 4.** The percentage damage to the stem for the seven species in the two study areas.

the least susceptible of all, with leader damage of just 10%. However, these results were not fully repeated in the proportion of trees which suffered from damage to their side-shoots. The incidence of this form of damage was relatively high in ash and oak as well as in Sitka spruce and Japanese larch (Figure 2). Values for beech of almost 50% for this form of damage are a cause for concern. In contrast, with the exception of ash in particular and, Japanese larch to some extent, the incidence of stem damage by bark stripping was generally low (Figure 4). Almost 80% of ash trees were found to suffer from stem damage, for Japanese larch the incidence of damage was just over 20%.

The incidence of damage to "sheltered" oak trees that is, the damage which occurred prior to sheltering was surprisingly high and approached that for unsheltered oak trees on the same site (Figure 1). For this species, most of the damage was in the form of damage to the side-shoots (Figures 3 and 5), with as much as 40% of this being moderate damage. As might be expected the period of exposure to rabbits would be directly related to the extent of damage; leading shoot damage was almost 70% in unsheltered oak (7 months exposure), while nearby sheltered trees suffered only 6% damage (Figure 2). Interestingly, this situation was reversed for the extent of stem damage, with sheltered trees having more than twice that of unsheltered, although both the magnitude and severity of the damage was decidedly lower overall (Figures 4 and 6).

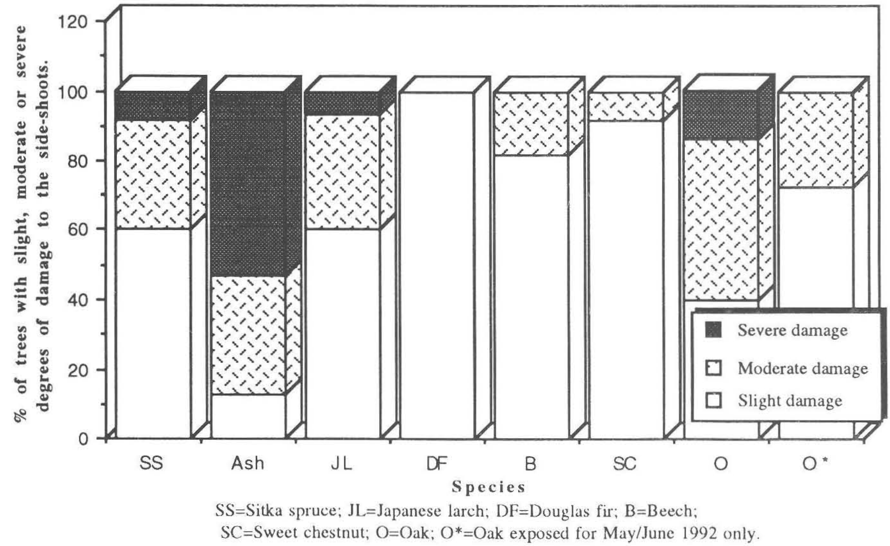


**Figure 5.** The severity of side shoot damage for the seven species in the two study areas.

Almost half of young beech trees suffered from damage to their side-shoots while 23.8% had the leading shoot removed. Beech had one of the lowest level of stem damage of all of the seven species studied, at less than 2%. Furthermore, all of this damage was classified as being slight. Sweet chestnut, with a moderate level of overall damage (31.4%), also had a relatively low level of side-shoot damage, at 21.3%. Less than a tenth of sweet chestnut trees suffered from bark stripping and the incidence of leader damage (6%) was the lowest of all seven species examined.

The percentage of trees which suffered some degree of damage was relatively high in two out of the three conifer species examined. Eighty eight point two percent of Japanese larch trees were damaged and 73.5% of Sitka spruce trees were similarly affected. The contribution of side-shoot and leader damage to the overall damage level was approximately equal for both of these species. In Douglas fir the percentage of trees which suffered any degree of damage was just 16.7%, with the incidence of leader and side-shoot damage falling to values as low as 10% and 11% respectively, with no stem damage being recorded.

Figures 5 and 6 show a classification of the degree of severity of damage for those trees which suffered side-shoot damage and stem damage, respectively. Of the seven species examined, ash was most vulnerable to severe rabbit damage. Over half of the side-shoot damage which occurred

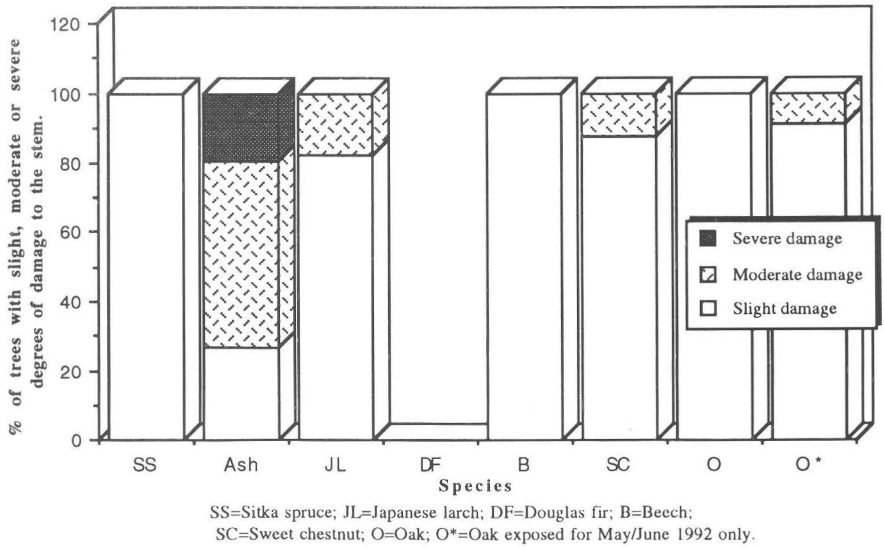


**Figure 6.** The severity of stem damage for the seven species examined in the two study areas.

was severe. In addition, 20% of stem damage was severe but a further 50% was moderate. Conversely, in the majority of cases both forms of damage to the other species was slight. However, Sitka spruce, Japanese larch and oak did display moderate side-shoot damage in 30% of cases (Figure 5). The incidence of moderate stem damage was generally lower and occurred in Japanese larch, sweet chestnut and oak (Figure 6).

The extent of overall damage was not related to rabbit activity levels. However, rabbit activity was found to be correlated with certain forms of damage, such as bark stripping and severe side-shoot damage.

## Discussion

The overall levels of damage which were found confirms the suspicion that the majority of young tree species can become damaged by browsing (Gill, 1992), with side-shoot damage proving to be the most important form of damage by rabbits. Certain species, such as ash and oak are preferred for browsing and these can become damaged in a relatively short period of time (Gill, 1992; Lanier, 1976), even when rabbit population levels are relatively low. The distinctive preference for species such as ash, oak, and Japanese larch shown in this study confirms early reports from Scotland (Craig, 1871).

Although there were four species identified which had a relatively high rabbit damage, much of the damage to Sitka spruce and to Japanese larch was slight and to the side-shoots. In addition to this it is known that Sitka spruce can withstand a greater degree of browsing than many other species (Melville *et al.*, 1983). Coniferous species are generally less vulnerable and the damage inflicted is not generally economically significant. Thus, the two species at greatest risk from rabbits are ash and oak. Little work has been carried out so far on the economic significance of this forest pest. The lack of information on the ability of trees to recover from browsing damage makes any calculation impossible. With the sole exception of ash, the incidence of stem damage in these young trees was low and suggests that this form of damage is not important in young plantations. Side-shoot damage appears to be a common form of damage even on non-preferred species, while leading shoots were often targeted on preferred tree species. Tree shelters proved to offer a satisfactory level of protection against leader damage in oak trees.

The extent of overall damage was not related to rabbit activity levels, but this was not thought to be a reflection of the situation in general. The size of the plot examined was too constrictive for any study of rabbit ranging behaviour. The distance from cover has been shown to be related to damage of winter barley (Cowan *et al.*, 1989), with the majority of rabbits staying within 20 m of the field margin. Ecological factors such as competition, availability of preferred species as well as various physical site variables may well be more important in tree plantations. However, rabbit activity was found to be correlated with certain forms of damage, such as bark stripping and severe side-shoot damage. These relationships are indicative of the situation in early summer, when population levels were relatively high. Shooting and poisoning activities on both sites caused a temporary reduction in numbers during the summer months and this may have effectively controlled the rabbit population and reduced the incidence of leader damage. However, we cannot rule out other, more complex ecological interactions which are likely to influence the selection behaviour of these animals. For instance, the relatively high incidence of side-shoot damage to oak trees in May and June may have been due to the unusually dry conditions that prevailed for those two months in 1992 (T. Keane, Meteorological Service, personal communication). A reduction in the availability of other more lush vegetation at this time could result in the selection of side-shoots, in order to provide sufficient water.

The degree of severity of damage to the leading shoot was not scored, due to difficulty in distinguishing between damage classes. Basically, the removal of a leading shoot is an "all-or-none" response, i.e. once the uppermost tip is removed, multi-leader development is likely. There is no evidence to suggest that there is a relationship between the length of leader which was removed and the extent of multi-leader development

(J. Fry, personal communication). Therefore, leader damage was simply classified as having a score of either 1 (leader removed) or 0 (no damage). With the exception of sweet chestnut, the inter specific differences in mean tree height were too slight to permit any meaningful comparison between rabbit activity and mean tree height.

Unlike deer, (Hannan, 1986), the species preferred for browsing by rabbits were not preferred for bark stripping, although susceptibility to bark stripping by rabbits may be related to the age of the tree (Gill, 1992). Several reasons have been cited for bark stripping; the shortage of other food, the need for vitamins or minerals otherwise deficient, (Miles and Kinnaird, 1979) or for the sugar content of soft tissues as in the case of the grey squirrel (Kenward, 1982). Damage to side-shoots was consistently high in species with high incidence of rabbit damage, while leader damage was restricted to just two species, ash and oak. Results from "sheltered" oak trees suggest that the side-shoots may be the first line of attack in preferred tree species but this requires further corroborative evidence. Furthermore, preferences for older shoots may become more apparent in older trees, as was found for hares (Ianson and Palo, 1991; Tahvanainen *et al.*, 1985) and this requires further investigation. The relatively low incidence of leader damage in sweet chestnut was due to the height of these trees when planted out in March/April 1992. All were greater than 60 cm in height and therefore could not be comfortably reached by the rabbits (Springthorpe and Myhill, 1985).

The factors which govern the selection of material for browsing are complex and the underlying principles have not been examined in any detail for rabbits (Miles and Kinnaird, 1979; Gill, 1992). Population size, habitat variables and the presence of certain resinous material (Moss, 1973), or secondary metabolites (Gill, 1992) have all been identified as possible contributory factors. The determination of the role of secondary metabolites as possible anti-browsant compounds, as carried out for hares (Ianson and Palo, 1991; Tahvanainen *et al.*, 1985), would be an important step forward. It may be possible that tree species such as oak, ash, Sitka spruce and Japanese larch may contain similar types and levels of these compounds. Preferences for older as opposed to younger shoots may become apparent in older trees.

In addition to this chemical factor, other important ecological variables have been identified, all of which are interrelated to a greater or lesser extent. These include the level of rabbit activity and future potential for an increase in numbers, habitat type, whether the site has been clear felled in the past, the amount of other browse available, the availability of suitable cover for the rabbits on the site as well as distance from areas of high rabbit activity to the site (Downes, 1993). In addition, there are various physical factors to be considered, such as soil type, the control methods (if any) used on the site and the time of year and weather conditions (Downes, 1993). Further work may clarify the exact ecological, physical and chemical mechanisms involved.

**Recommended Control Measures**

The importance of adequate assessment of the site at least three months prior to planting, in order to prevent subsequent damage occurring cannot be emphasised strongly enough. Assessment of the numbers of rabbits which are present on, or very close to a proposed site is not sufficient on its own, without an estimate of the future potential for recolonisation from neighbouring land (Springthorpe and Myhill, 1985). Waste material, such as large piles of tree stumps and brambles, if left on the new plantation create ideal habitats for rabbits and should be cleared. Species vulnerability as well as plot size are important considerations in deciding on preventative measures such as fencing or tree shelters. Therefore, any pre-planting assessment plan is certainly likely to substantially reduce any costs that might be incurred as a result of serious rabbit damage and is strongly recommended.

**Conclusions**

Rabbits are capable of causing severe damage to young tree plantations in relatively short periods of time even when population numbers are relatively low. Oak, ash, Sitka spruce and Japanese larch were identified as being vulnerable to rabbit damage, although there were differences in the form and severity of damage for these species. Sweet chestnut, beech and Douglas fir all suffered relatively low levels of damage. Damage to the side-shoots was consistently high for all four vulnerable species, but the incidence of leader loss was highest for oak and ash. Serious stem damage was found in ash. Ash was the most vulnerable tree species by far, with a high incidence of all three forms of damage, a large proportion of which was severe in nature. In contrast, Douglas fir was the least susceptible to damage by rabbits and any damage which occurred was slight.

It is clear from this study that measures to understand the relationships that exist between the nutritional ecology of the European wild rabbit and the health of young forestry plantations will substantially reduce the economic losses incurred in the future. Such information is essential for future planning and management programmes, particularly in view of current high rates of planting and the diversity of site types.

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