Chapter (non-refereed)

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30. GREY SQUIRREL DAMAGE AND MANAGEMENT

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Grey squirrels *(Sciurus carolinensis)* became established in Britain after being released at several sites between 1876 and 1910 (Middleton, 1931). They now occur in lowland woodlands in most of the country, largely replacing the native red squirrel *(Sciurus vulgaris).* Since the 1930s, grey squirrels have been considered as pests, partly because of damage they do to stored grain, fruits, vegetables and wild life, but mainly because of sporadic episodes when forest and woodland trees are subject to severe bark-stripping (Shorten, 1957, 1962). The growth of the worst affected trees, typically sycamore *(Acer pseudoplatanus),* beech *(Fagus sylvatica)* and oak (*Quercus* spp.), may be stunted as a result of stem ring-barking with subsequent death of the upper crown; when bark removal is extensive trees may be killed outright. Removal of lesser quantities of bark may decrease timber quality and possibly facilitate colonisation by fungi (Plates 22 and 23).

1. Past and present

At first it was thought that the damaging grey squirrel could be exterminated from Britain, but a bounty scheme to encourage its eradication prevented neither the spread of squirrels nor their damage. Since bounty payments were abandoned in 1958 (Thompson & Peace, 1962), attempts at control have been organised locally (Rowe, 1973), trapping proving to be more effective than shooting (Taylor, 1963). In 1973, a Parliamentary Order permitted the use of hoppers containing warfarin-treated grain. However, bark-stripping is not always prevented by reduction of a local squirrel population, and a drawing-in of squirrels to bait may even temporarily increase damage (Taylor, 1966, 1969). Moreover, other species are susceptible to poisoning, either directly from hoppers (Wood & Phillipson, 1977), or perhaps secondarily by eating dead squirrels (Marstrand, 1974).

An understanding of why a species causes damage can sometimes help the development of effective prevention techniques. At least 9 suggestions have been advanced to explain why grey squirrels strip bark: shortages of food or water, trace nutrient deficiencies, a liking for sweet sap, the collection of nest material, a persistent gnawing reflex, the prevention of incisor overgrowth, and agonistic display or territorial boundary marking (Allen, 1943; Shorten, 1954; Taylor 1966; Davidson & Adams, 1973). Of these suggestions 4 can be discarded:

a) Water shortage is an unlikely cause of bark-stripping, because trees by open water are stripped (Seymour, 1961); furthermore, damage to woodlands during the wet summers of 1977 and 1978 was sometimes severe.

b) Squirrel dreys are lined with bark finer than that from tree stems, which is dropped to the ground (Shorten, 1954).

c) Instead of a territorial social structure, squirrels have a dominance hierarchy (Taylor, 1969; Thompson, 1978) with bark-stripping not always occurring where boundaries might be expected.

d) Tooth wear is minimal because bark is removed by pulling instead of gnawing. Thus, bark-stripping is unlikely either to decrease incisor overgrowth or to result from a simple gnawing reflex. After bark stripping, squirrels scrape and eat the soft sap-containing vascular tissues (Taylor, 1969).

In contrast, there is evidence to support the 'agonistic display' and food shortage theories. Bark damage in Britain is seasonally most severe during mid-summer, when small body weights, diverse diets and the ready acceptability of bait suggest food shortages, bark damage often occurring in supposedly poor habitats (Taylor, 1969); squirrels observed bark-stripping by Taylor were nearly all juveniles or subadults (1 year old). Mid-summer is also a time when squirrels disperse and when agonistic encounters, which may include gnawing, occur most commonly. Taylor has suggested that bark-stripping is caused by inferior squirrels which move into inadequate habitat and engage in agonistic gnawing while establishing a social order, so discovering that sap is an acceptable food. But, because the sap appears to have a small energy content (D.A. Wood, pers. comm.) food shortage is unlikely to be the only factor causing extensive bark-stripping. In an oak-maple plantation in Minnesota, bark-stripping occurred even when acorns were available (Irving & Beer, 1963); in another instance, the provision of food did not prevent similar damage by fox squirrels *(Sciurus niger)* (Allen, 1943); in Britain, cambium was found in the stomachs of adults and individuals with large body weights shot in a damaged area (MacKinnon, 1976). However, sap, because of its sugar content, might be preferred food. Amounts of assimilable sugars are maximal in sycamore sap in mid-summer (Cockerham, 1930), this species, *A. pseudoplatanus,* being congeneric with the sugar maples *(Acer saccharum)* which appear to be "limited by incessant squirrel damage" in some parts of the USA (Brenneman, 1954). Nevertheless, a preference for a low-energy food would seem inappropriate. If this is so, sap containing tissues may be eaten to obtain one or more temporarily deficient trace nutrients.

If and when the causes of bark-stripping are known, it may be possible to improve squirrel management with the evolution of new methods of control. If immigration causes agonistic encounters which trigger extensive bark-stripping, then the recommended practice of decreasing squirrel numbers in damage-prone areas during spring may not only be ineffectual, but also counter-productive, because reducing the resident squirrel population could increase immigration (Taylor, 1969). A more effective method might be to reduce squirrel populations in good habitats adjacent to vulnerable areas. If food shortages were responsible for extensive bark-stripping, the level of damage might be predicted by relating spring squirrel populations with food availability. If the need for a trace nutrient were the cause of damage, perhaps the deficiency could be minimized artificially, eg by providing a 'squirrel-lick' which could become the basis of a new and possibly selective method of trapping and which would not jeopardize other wildlife.

2. The future

Five approaches are envisaged including removal experiments, radio-tagging, analysis of (i) stomach contents and (ii) plant vascular tissue composition, and experiments with captive squirrels.

2.1 Removal experiments These will be done in 2 woodland areas each with mature oak and ash and adjacent to young plantations in which beech, oak and sycamore were damaged by squirrels in 1977 and 1978. In one set of locations, the controls, the natural course of events will be followed. In the other, some, but not all, of the squirrels will be removed from the young plantation so as to investigate effects of the remnant population on immigrating squirrels, their nutritional condition and bark-stripping activities. If removal of squirrels from a damage-prone young plantation, with adjacent mature woodland, increases immigration or otherwise favours bark-stripping, then effects of removing squirrels from the mature woodland will be investigated.

2.2 Radio-tagging In the control area of the removal experiment, some squirrels will be fitted with collars having radio transmitters so that their movements can be readily monitored without the need for baited traps, which may themselves influence feeding patterns. Radiotagging will also be used to identify the age, sex, body weight, range size and activity of individual squirrels so facilitating comparisons between those that do, and do not, strip bark. A radio receiver, which can be programmed to scan each transmitter frequency in turn for several seconds and which records automatically on paper tape, will be mounted at the base of trees subject to stripping so that the squirrels responsible can be identified and their periods of activity recorded. At present, the radio-collars are being tested to see if they adversely affect squirrels and their movements, comparisons being made with others marked by toe-clipping. By 22 October 1978 6 transmitters had been 'worn' for a total of 298 days without a death. Transmitter ranges in woodland are about 400 m and 1 km when squirrels are on the ground or in trees respectively.

2.3 Analyses of stomach contents The stomach contents and condition of dead squirrels from damaged woodlands will be analysed to see if dietary deficiencies can be detected.

2.4 Sap composition The content of sugar and of other nutrients in vascular tissue samples from damaged and undamaged trees will be analysed.

2.5 Experiments with captive squirrels Hand-reared squirrels will be kept in an enclosure for attempts to develop traps which selectively capture bark-stripping squirrels. If wild squirrels that strip bark appear to be short of major or minor nutrients, the diets of captive squirrels could be manipulated in an attempt to induce bark-stripping, with the possibility of diet supplementation trials in the wild.

While the work just outlined is being done, B. Don at Oxford University will be adopting a different approach to the squirrel problem. He will be studying relationships between woodland structure and squirrel damage to see if forest management can play a part. The role of NERC in conservation research is well known, usually in the context of protecting species and habitats. In the event the conservation of species such as beech, oak and sycamore may necessitate the local destruction of another species, namely the grey squirrel.

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