

Red squirrels and forestry – is it time for a review of policy and practice?

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Introduction

Unlike other rodents, the red squirrel (*Sciurus vulgaris*) is universally loved, even voted the second most popular animal in Scotland (**Figure 1**). Supplementary food is provided in countless gardens, and thousands of sightings are reported annually to the Saving Scotland's Red Squirrels (SSRS) initiative. Community conservation action is widespread, with 19 groups and hundreds of volunteers working to protect red squirrels from the threat posed by the invasive North American grey squirrel (*Sciurus carolinensis*).

With this level of interest, it is not surprising that forest managers are frequently contacted by the public expressing concerns about the impact of felling. It's an emotive issue, and no doubt seeing red squirrel habitat 'destroyed' upsets many who may consider felling of plantation trees a threat to red squirrel conservation in Scotland.

To their credit, much effort is expended by forest managers and government agencies in trying to reconcile the welfare and

legal protection of red squirrels with the production of timber, a commodity of national importance. Forestry operations in important squirrel forests are frequently rescheduled to avoid breeding season; pre-operational surveys are conducted and felling work is often postponed if dreys are located; and site-specific mitigation is often developed to minimise possible impacts on squirrels, including retention of drey trees and felling in directions that make it as easy as possible for squirrels to relocate into adjacent crops. Not surprisingly, this additional management and mitigation increases operational costs, ultimately passed on to consumers. For Forestry and Land Scotland (FLS), an executive agency of the Scottish Government, the annual management and forgone revenue costs associated with red squirrels are estimated to run into hundreds of thousands of pounds (Kortland, personal observation).

In addition to these management activities, which are employed throughout the extensive range of the species, 19 Red Squirrel Strongholds were designated by Forestry Commission Scotland in 2009. Of these, 18 encompass over 115,000ha of mainland Scotland, and the 19th is the entire island of Arran. Specific management to benefit red squirrels is recommended for these strongholds, such as maintenance of certain proportions of age classes in the timber crop (Forestry Commission Scotland, 2012).

Given that red squirrels are a significant constraint on timber production activities, and that special measures are expected in large areas of managed woodland, it is important that mitigation and management recommendations are evidence-based and targeted. So it is surprising that very little applied research has been undertaken on this high-profile species. To try to address this knowledge gap, FLS and private forest managers have been collaborating with a range of academic partners to enhance the scientific underpinning for red squirrel management in productive forests. This included radio-tracking of red squirrels, under licence from NatureScot. The aim is to review site-level concerns and practice, and inform future policy.

Impacts of forest operations on individual squirrels – thinning

In 2017, 22 red squirrels were captured and fitted with radio collars (**Figure 3, page 34**) in a mixed-conifer forest near Ferness, in the Highland Council area (de Raad et al., 2021a). The aim was to measure the response of individuals to a standard thinning operation, which reduced the basal area of the predominantly Scots pine (*Pinus silvestris*) and Norway spruce (*Picea abies*) crop from 42m²/ha to 32m²/ha. The squirrels were tracked before, during and after thinning, carried out during the last three weeks of May 2017. All work was appropriately licensed.

The study showed survival was relatively high compared to sites without forest operations, and breeding activity continued with no detectable impact from forest operations. Population density was higher after the thinning operations. Whilst space use changed for a handful of individuals, requiring squirrels to build new dreys (which red squirrels can do in a few days (Bosch et al., 2013)), home ranges and core areas did not significantly change overall. The findings indicated that the impact of standard thinning operations on red squirrels during breeding season was minimal.

In a parallel study, the efficacy of pre-operational drey surveys were also investigated (de Raad et al., 2021b) by comparing the survey observations with radio-tracking data.

Figure 1, above left: *Sciurus vulgaris* © Andrew Jarrott

Figure 2, right: Red squirrels can carry large young to alternative dreys © Forestry and Land Scotland



The results showed that the survey missed over 80% of dreys known to be present (and in use). Only 47% of dreys identified by the survey were confirmed to be in use by the end of the study. In other words, 53% of dreys identified during the pre-operational survey were likely to be abandoned or no longer in use. These findings reflect the difficulty of detecting squirrel dreys in dense conifer canopy, and suggest that pre-operational drey surveys are an ineffective use of time.

In a follow-up study at two further thinning sites at Cawdor Estate (Meikleburn) and Tolquhonie woods near Carrbridge, ten and 11 red squirrels were tagged and tracked respectively (de Raad et al., in preparation). Preliminary results show that drey surveying was similarly inaccurate as in Ferness, with surveys missing 92% and 98%, respectively, of the dreys in use (as confirmed by radio tracking). During this study, drey trees that were located through radio tracking, and thereby known to be used by red squirrels, were marked inconspicuously, such that the harvester operator would not know the trees contained dreys. Interestingly, at the end of the thinning operation, it was found that only 3–14% of the trees containing dreys had been cut down.

Impacts of forest operations on individual squirrels – clear felling

The follow-up study investigated the response of squirrels to clear-felling. In 2020, red squirrels were fitted with radio collars, across three privately-owned forest blocks and in one owned by FLS. Although full analysis of the spatial data is ongoing at the time of writing, some interesting findings were presented in an interim report (de Raad, 2022).

Firstly, several squirrels dispersed quite long distances before any operations even commenced. For example, one male travelled 4km through woodland to another forest block, whilst a female dispersed 5.25km to another site through a matrix of open ground and woodland, and even crossed the River Findhorn. This behaviour is not unusual, and is thought to be in response to the temporal and spatial variation in tree seed crops, the squirrels’ primary food supply, as well as movements by males in search of females during breeding periods (Lurz et al., 1997). Other studies have recorded frequent dispersal events, including extremely long distances of up to 16km (Hämäläinen et al., 2019). This suggests that even when clearfelling takes place at reasonably isolated forest blocks, both female and male squirrels are likely to be able to move into nearby forests, even if this requires crossing open habitat.

Secondly, as clearfelling progressed on the study sites, the resident squirrels congregated in the shrinking area of remaining crop within the forest block. As this got smaller,



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The authors have been collaborating on applied squirrel research since 2014, initiated by Forest Enterprise Scotland (now Forestry and Land Scotland) and Inverness College UHI with the aim of more effectively reconciling red squirrel conservation with timber production. The project is backed by Confor’s Forest Industry Environment Group, and several private estates give invaluable support. The initiative brings biologists together with the forestry sector to achieve mutually beneficial outcomes.

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some individuals, who had lost all or most of their home range, started exploratory visits into adjacent crops. This continued as available habitat shrank further until, eventually, all the squirrels had dispersed into adjacent crops. Thereafter, they settled in these nearby areas, where they built new dreys for shelter. This work highlights the need to employ a squirrel-friendly direction of felling, to avoid isolating squirrels in a clump of trees surrounded by open ground, including clearfells and moorland, such that they are forced to disperse across areas with no cover, where they are vulnerable to predators.

During the study period of the radio-tracking work outlined above, the squirrels used between six and 19 dreys. Other studies showed that squirrels used between two and eight at any one time (Lurz, 1995). Whilst young are usually raised in a specific breeding drey, they are on occasion moved by the female squirrel to another drey (**Figure 2, page 33**). One red squirrel has been observed carrying large young over 100 metres from one drey to another (Kortland, personal observation). It is probable that, in response to clearfelling activity, red squirrels will move young, although this has yet to be shown in radio-tracking studies and warrants investigation.

Designated red squirrel strongholds – is special management needed?

Within designated red squirrel strongholds, management in accordance with specific guidance (Forestry Commission Scotland, 2012) is recommended. However, adherence to this guidance is difficult, given the wide range of other pressures, restrictions and timber market fluctuations facing forest managers. Consequently, suggested measures have not been widely adopted.

To investigate the importance of the recommended specific management, Slade et al. (2020) developed a spatially explicit mathematical model to assess the population viability of red squirrels in designated forest strongholds in Scotland under the implementation of two forest management policies: specific management for red squirrel conservation, as per the published guidance (Forestry Commission Scotland, 2012), compared to the multi-purpose UK Forestry Standard for sustainable forest management.

The study clearly showed that, in the presence of grey squirrels, the specific management policy provides an advantage to red squirrels over grey when compared to the UKFS, and its implementation supports red squirrel conservation efforts. However, when grey squirrels are not present, there is no discernible benefit in the specific management policy compared to the UKFS. The model results therefore indicate that species-specific forest management for red squirrel conservation in the absence of sympatric grey squirrels is not required. In other words, in the absence of grey squirrels, red squirrel populations are viable in forest landscapes managed for timber production, without the need for additional measures. Red squirrel-specific management should be reviewed and targeted only at strongholds with sympatric grey squirrel populations.

Natural strongholds

The current set of 19 red squirrel strongholds was identified by public consultation in 2009, rather than population modelling based on forest characteristics critical in red-grey competition. In the resultant guidance, there is a commitment to evaluate the strongholds programme. Partly to this end, Slade et al. (2021) developed their population modelling work to identify existing forests that can successfully support red squirrels under UK Forestry Standard management. The modelling indicated that if current levels of grey squirrel control are continued, there will be large expanses of forest in northern Scotland that support viable red squirrel populations



Figure 3, above: A red squirrel wears a radio collar. © Louise de Raad

without the need for species-specific management.

In a worst case scenario, where grey squirrels had expanded to all regions in Scotland, the model identified forest regions – denoted as ‘natural strongholds’ – that could support red squirrel populations due to their favourable forest composition, even in the presence of grey squirrels. However, the authors note that the natural strongholds are relatively small and isolated, so additional conservation action would be necessary to maintain the genetic viability of the isolated red squirrel populations (e.g. through periodic translocations of red squirrels).

The results of this work also showed that the locations of the natural strongholds do not match the 19 designated forest strongholds in Scotland (**Figure 4**; officially designated strongholds are outlined in black). The research concluded that natural strongholds could offer long-term protection to red squirrels against grey squirrel invasion, without the specific management required in designated strongholds.

Conclusions

The research outlined here has shed some important light on red squirrels in a productive forestry context. Red squirrels appear able to cope with standard thinning operations without significant detriment to survival or breeding success, in contrast to the widespread former assumption that such activity would be very damaging. Under the Wildlife and Countryside Act (1981), it is now possible to obtain a licence for work that might affect red squirrels, including for economic reasons. The findings of the recent radio-tracking studies carried out by de Raad (2021a and 2021b) should help to facilitate the licensing of thinning operations, even during breeding season, if there is no satisfactory alternative.

It was clear that pre-operational drey surveys are very ineffective, locating a small proportion of active dreys. Pre-operational surveys should focus on determining squirrel presence or absence, based on other field signs such as chewed cones. Alternatively, where red squirrels are known to be present, licences should be sought automatically, based on the assumption of squirrel presence in the felling coupe. This would increase the number of licence applications relating to red squirrels, so development of a Standard Forestry Operations Licence may be advisable – at least to cover thinning operations. Such a licence, currently available from NatureScot for badgers, reduces bureaucracy considerably.

With clearfell, it is obvious that red squirrels are displaced and that drey trees will be felled. Squirrels are effective dispersers, and moving to new territories is a natural part of their behaviour (Wauters et al., 1995). However, as clearfell

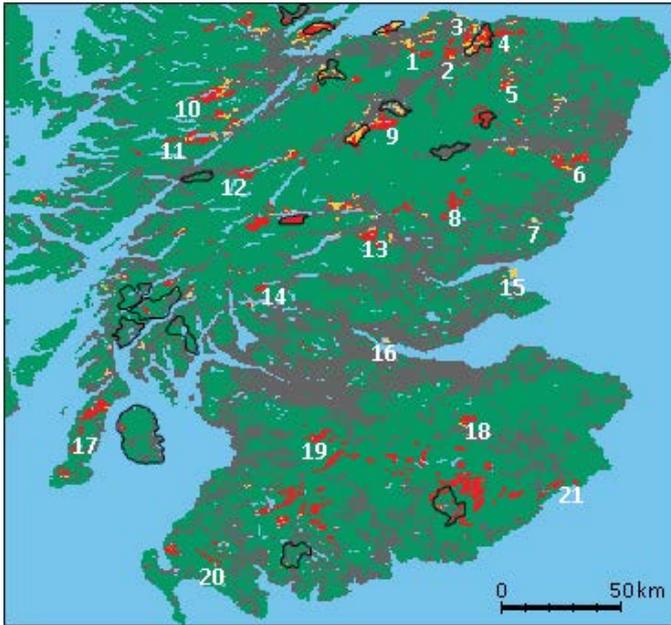


Figure 4, above: Forest regions of Scotland that act as natural strongholds (shown in red) and support red squirrels against grey squirrel incursion (yellow areas show suitable grey squirrel habitat near strongholds). 1. Newtyle Forest, 2. Elchies Forest, 3. Teindland Forest, 4. Aultmore, 5. Clashindarroch Forest, 6. Fetteresso Forest, 7. Montreathmont Forest, 8. Glenisla Forest, 9. Glenmore Forest Park, 10. Glen Affric, 11. Glen Garry, 12. Glen Spean, 13. Craigvinean Forest, 14. Loch Doine, 15. Tentsmuir Forest, 16. Kincardine, 17. Kintyre peninsula, 18. Glentress Forest, 19. Muirkirk, 20. Newton Stewart, 21. Wauchope Forest. The 19 currently designated strongholds (Scottish Forestry, 2020) are outlined in black. Map from Forestry and Land Scotland (2020).

involves complete removal of habitat from a given area, steps should be taken to facilitate dispersal into adjacent forest blocks. In the long term, more work needs to be done to understand not only the dispersal patterns of squirrels leaving a clearfelled region, but also the costs of such forced dispersal in terms of survival of the dispersing animals and the resident squirrels that have to accommodate these sudden immigrants.

At the population level, the modelling work by Slade et al. (2020 and 2021) indicates that, in the absence of grey squirrels, red squirrels and forestry are compatible. Red squirrel populations are viable in landscapes managed for timber under the UKFS, without the need for special management. However, in a further modelling exercise to assess the impact of the removal of larch (*Larix* spp.) infected by *Phytophthora ramorum* on the Cowal peninsula (Slade, White & Lurz, 2021), population viability was enhanced by an increase in tree species diversity within the forest. Furthermore, natural strongholds exist wherein red squirrels will be able to persist even if grey squirrels expand their range throughout Scotland and overlap with the entire range of red squirrels. Interestingly, these natural strongholds do not match exactly the 'official' strongholds that were designated previously. As suggested by Forestry Commission Scotland (now Scottish Forestry) in 2012, an evaluation of the stronghold programme should now be conducted on the back of the research summarised in this paper.

It is clear from these latest findings, and from a cursory look at red squirrel distribution in Scotland, that the forestry sector and the plantation habitats it creates are overwhelmingly beneficial for red squirrels. Some dreys will be felled, and a proportion of squirrels will be forced to disperse, in the course of timber production, but this is far outweighed by the benefits provided by plantation habitats. Availability of plantation

habitat changes in space and time as crops are planted, grow, mature and are felled. Red squirrels are able to cope with forestry activity at site level and are naturally well adapted to dispersing within this shifting mosaic of management. Staff of statutory and conservation bodies, and squirrel conservation advocates, should have this wider context at the forefront of their thinking when authorising or assessing site-level forestry work that may affect a local population of red squirrels.

Pragmatism is ever more crucial as timber imports increase (Forest Research, 2021), leading to significant environmental impacts associated with timber transport, and with a proportion of the timber undoubtedly sourced from natural woodlands and uncertified plantations elsewhere in the world. If the research outlined in this paper is used to inform management, the planned expansion of woodland and timber production in Scotland – in line with Scottish Government targets – will all be of benefit to our beloved red squirrel.

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