

# Where are all the red squirrels?



Red squirrel in Scotland

As recently as 150 years ago, only red squirrels lived in the UK. So, where did grey squirrels come from, what has happened to the reds, and should we be doing anything about this? Geneticist Kevin O'Dell investigates

Kevin O'Dell

## Exam links



**AQA** Populations in ecosystems

**Edexcel A** Numbers and distribution of organisms in a habitat are controlled by biotic and abiotic factors

**Edexcel B** The effects of biotic and abiotic factors on population size

**OCR A** Interactions between populations

**OCR B** The impact of population increase

**WJEC Eduqas** The regulation of populations by density dependent and density independent factors

The second half of the nineteenth century was a period of great discovery. If you were rich, or could find a sponsor, you could travel around the world acquiring interesting 'exotic' non-native species. While some new non-native species have a benign effect on their new environment, others outcompete the native

species, and may even drive those **indigenous species** to extinction. In recent years many agencies have developed plans to rid countries of some of the more problematic introduced **invasive species**. For invasive plants this is rarely controversial and concerted efforts are in place to eliminate rhododendron (originally from Asia and North America), Japanese knotweed (from east Asia) and other invasive plants from the UK.

Red squirrels are thought to have arrived in the UK around 10 000 years ago, by crossing the land bridge that is now the English Channel at the end of the last ice age. In the mid-nineteenth century red squirrels were thriving across the length and breadth of the UK. In 1876, competition arrived in the form of the first grey squirrels, which were released in England at Henbury Park in Cheshire. It soon became apparent that grey squirrels were very successful in their new environment. As a consequence, they had a catastrophic effect on the red squirrels. Now, 150 years or so later, for every red squirrel in England's green and pleasant land, there are approximately 70 grey squirrels.

Grey squirrels are native to the eastern and midwestern USA, as well as the southern districts of the eastern provinces of Canada, in an area lacking red squirrels. Molecular evidence — a comparative analysis of DNA sequences





**Figure 1** View of Sandbanks, part of Poole in Dorset, with Brownsea Island in Poole Harbour in the distance. Brownsea Island, which is just 200 hectares of woodland, heathland and salt marsh, is one of just two remaining refuges of wild red squirrels in southern England. The other is the Isle of Wight

from the two squirrel species — suggests that they diverged around 8 million years ago.

Since grey squirrels were introduced to the UK, the UK red squirrel population has plummeted from an estimated 3.5 million in 1876 to around 140 000 today. The surviving UK red squirrels are not randomly distributed across their previous range. The red squirrel population of England may now be as low as 15 000, with the last remaining strongholds being found in Northumberland, the Lake District and Brownsea Island in Dorset (see Figure 1). Larger, but still declining, populations of UK red squirrels survive in Scotland, and to a lesser extent in Wales and Northern Ireland (see Figure 2).

### How and why do greys outcompete reds?

Like many conservation issues, nothing is quite as simple as it may at first appear. There is no single reason why grey squirrels have so successfully outcompeted UK red squirrels for the last 150 years or so. Conservation

researchers in the UK have identified five key contributors to red squirrel decline, all except one of which is strongly linked to the introduction of grey squirrels.

#### 1 Size matters

Grey squirrels are bigger and more aggressive than red squirrels. However, there is little or no evidence that the two species fight. So, while grey squirrels don't kill red squirrels it is thought that the more aggressive greys are more successful when the two species compete for limited food resources (that greys can actively defend and protect from the smaller, weaker reds).

#### 2 Feeding strategy

A favourite food source for both grey squirrels and red squirrels is acorns. Both species prefer green, immature acorns, so if both species arrive on the scene at the same time, the more aggressive grey squirrels may devastate the acorn crop before the red squirrels get a chance to eat. Red squirrels favour the green acorns because they find it difficult to digest the polyphenols in brown (mature) acorns.

In 1993, researchers fed six captive grey squirrels and six captive red squirrels a mixed diet of mature acorns, peanuts, carrots, apples, hazelnuts and

### Terms explained



**Coniferous woodland** A woodland that predominantly or exclusively comprises conifer trees.

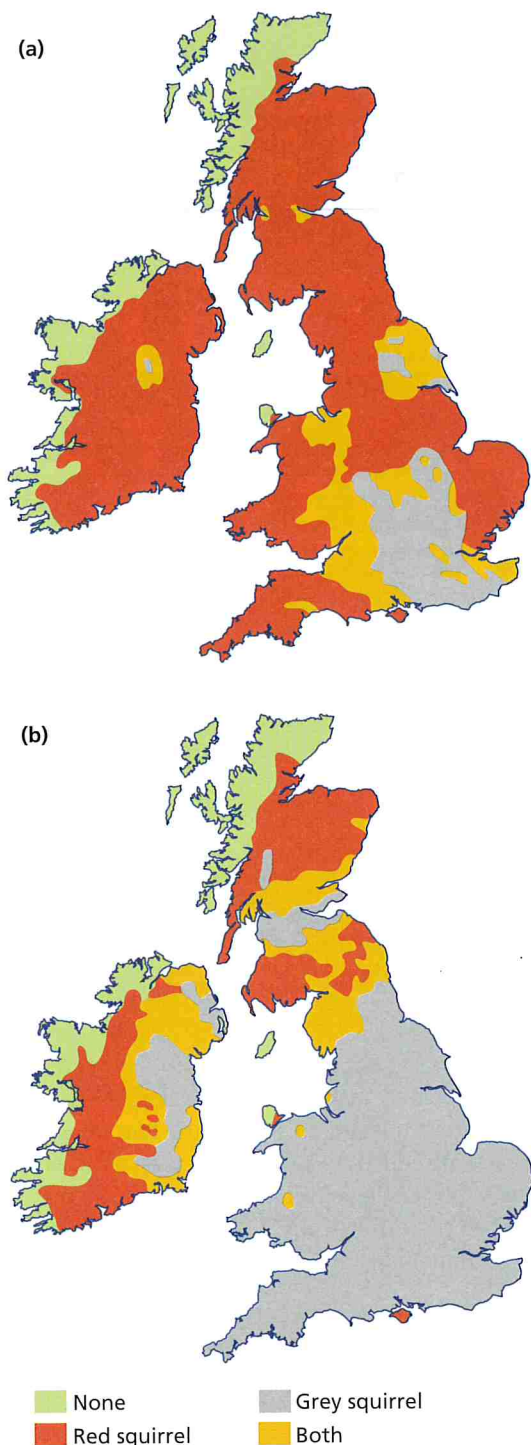
**Fecundity** The ability to produce increased numbers of offspring.

**Indigenous species** A species that has been living in an environment for a long time, or at least before people arrived in that environment.

**Invasive species** Species of plants and animals that have been introduced to new environments by people, outcompeting indigenous species.

**Targeted cull** The deliberate killing of a specific species.



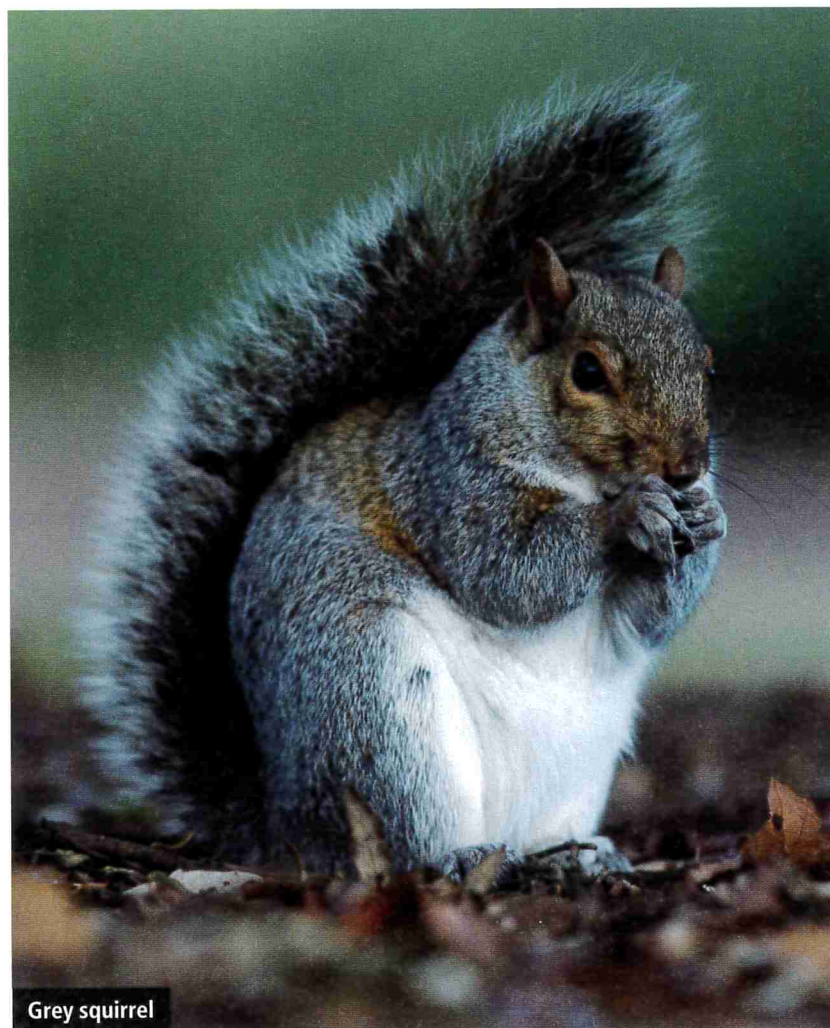


**Figure 2** Distribution of red and grey squirrels in Great Britain (a) in 1945 and (b) in 2010

sunflower seeds. The grey squirrels readily ate all the foods, whereas the reds avoided the mature acorns. When the diet was restricted to mature acorns alone, the red squirrels suffered significant weight loss caused by intestinal inflammation, but all six grey squirrels increased their weight.

### 3 Breeding strategy

Healthy grey squirrels and red squirrels have similar breeding potential, with roughly the same litter



Grey squirrel

sizes. However, grey squirrels often have two litters a year (in spring and summer) whereas red squirrels normally only have one litter in spring. Successful breeding is in part linked to the health, and particularly the weight, of female squirrels. So, where populations overlap, competition for food, especially green acorns, effectively restricts the diet of red squirrels, reducing their **fecundity**.

### 4 Disease

Grey squirrels often carry squirrelpox virus, but there is no evidence that this virus is in any way deleterious to their health. Researchers suspect that squirrelpox virus originated in grey squirrel populations in the USA and was brought to the UK by infected grey squirrels. Around 80% of UK grey squirrels show evidence of having been infected with the squirrelpox virus. However, when it infects red squirrels, the virus causes swollen lesions to the face, ears, feet and flanks, and kills about 90% of infected red squirrels within a couple of weeks. How squirrelpox virus is transferred between the species is not known, but the evidence that it is passed from greys to reds is overwhelming.

### 5 People

The decline of almost every native wild species is influenced by people. In the UK, for example, a major factor in the decline of red squirrel populations is the continuing loss of native woodland. Around 4000 years ago, most of the UK was covered in mixed native woodland, but progressive deforestation has seen the area of the UK covered by native woodland decrease to around 20%. Deforestation affects both squirrel species and many other species too, so we



cannot blame this aspect of red squirrel decline on the grey squirrels. Likewise, many squirrels are also killed in road traffic accidents.

### Gause's law

In 1932, at just 22-years-old, Russian biologist Georgy Gause published what is generally referred to as the competitive exclusion principle, or Gause's law. This law states that two species with similar ecological niches cannot coexist in a stable equilibrium while ecological factors remain constant. In other words, two species with essentially the same requirements for food and space cannot co-exist. The outcome is inevitable, in that the fitter of the two species will always outcompete the relatively less fit species. As there is around a 75% niche overlap between red and grey squirrels, with the grey being the fitter of the species, Gause's law suggests the extinction of red squirrels in the UK is inevitable. Conservationists predict that without human intervention red squirrels will be extinct in the UK by 2030.

### What can we do?

Whatever aspect of biological research a scientist is working in, it is a good idea to take inspiration from evidence from the natural world. In this case, we might ask why red squirrels survive relatively successfully in some parts of the UK, yet have been completely eliminated from others? What is different about these regions? Research has revealed that most remaining UK red squirrel populations are restricted to **coniferous woodlands**. It follows that management of these habitats might be able to help red squirrels survive. To achieve this, woodland agencies could manage the woodland habitat in such a way that it is as attractive as possible for red squirrels, but as unattractive as possible for grey squirrels.

The key to red squirrel woodland success is having a healthy food supply available all year round. Red squirrels feed primarily on seeds and nuts, but in the absence of these they also eat fruit, plant shoots and fungi. It is therefore important to ensure that the woodland has conifers. But conifers don't necessarily produce seeds every year, and only start producing seeds when they are around 20 years old. So woodlands need to be managed to ensure there is variety in the age of the trees present, as well as providing a variety of tree species, especially conifers, on which the red squirrels can feed. Red squirrels apparently prefer conifers with large seeds, such as larch and Norway spruce.

Conifer seeds are unattractive to grey squirrels, which need a food source with a higher energy content. So destroying broad-leaved trees in the coniferous woodland disadvantages the grey squirrels. Similarly, it is better to have islands of coniferous woodland that can only support red squirrels, with some form of barrier between the woodland and any surrounding grey-squirrel-friendly areas. These barriers can include arable land or moorland that discourage grey squirrels from approaching or entering the red squirrel habitat.

Woodland management alone is unlikely to return the red squirrel to its former status, and UK conservationists are now having to ask some difficult questions. It is unlikely that a vaccine against squirrelpox virus will appear in the near future, so conservationists are looking at ways of actively controlling the grey squirrel population.

Research from other countries with experience of controlling invasive species (see *BIOLOGICAL SCIENCES REVIEW*, Vol. 32, No. 3, pages 7–11) suggests that

### Further reading

The Woodland Trust has a blog dedicated to red squirrel conservation:  
<https://tinyurl.com/yfpq5tvz>

The Wildlife Trust has a website dedicated to red squirrel survival:  
<https://tinyurl.com/yg5qxak8>

## Exam-style questions

- 1 Tannins are found in unripe, green acorns. The tannin is lost as the acorns ripen. Unlike grey squirrels, red squirrels suffer tannin poisoning. Suggest why this has led to a loss of red squirrel populations in oak woodlands. [2 marks]
- 2 As long as grey squirrels are not present, red squirrels can live in a variety of habitats. Use Gause's law to explain why red squirrels are largely confined to coniferous woodlands in the UK. [3 marks]
- 3 Give **two** reasons why the loss of red squirrel populations in the UK could be blamed on human activity. [2 marks]

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targeting contraceptives at grey squirrels, or using humane capture of grey squirrels, is unrealistic. So the only option would appear to be a **targeted cull** of grey squirrels. But is that something that conservation biologists should do?

### Things to discuss

- Should we cull some, most or all grey squirrels living in the UK to ensure that the native red squirrels do not become extinct?
- How do you think squirrelpox virus is transferred between the two squirrel species? How would you test your theory?
- Populations that are exposed to, and infected by, a virus over many generations tend to become resistant or tolerant to that virus. But when the virus is introduced to a new population it can often have a devastating effect. Why do you think that is and can you think of any similar examples in fairly recent human history?

Kevin O'Dell is professor of behaviour genetics and dean of public engagement at the University of Glasgow. He is an editor for *BIOLOGICAL SCIENCES REVIEW*. He favours a cull of grey squirrels if that is the only way of ensuring that the UK's population of red squirrels survives.

### Key points

- Since the arrival of invasive grey squirrels in the UK 150 years ago, the indigenous red squirrel population has suffered a catastrophic decline.
- Without human intervention, the UK red squirrel population will be effectively extinct by 2030.
- UK conservation groups are urgently developing strategies to enable the UK red squirrel population to survive.