

The Grey Squirrel as an Invasive Non-Native Species

Background

Organisms that are imported to locations outside of their native range can become invasive. This happens when they are introduced into an ecosystem where they have no natural predators and/or well-matched competitors, making it easy for them to proliferate. Not all non-native species become invasive, but if they do, they can have major negative impacts on their host environment and can even drive the extinction of native species^{1,2}. For this reason, invasive non-native species (INNS) are now recognised as one of the five direct drivers of global biodiversity loss³. The Scottish Government highlighted the threat of INNS to Scotland's biodiversity in their 2013 supplement to the Scottish Biodiversity Strategy, citing them as a top priority for action⁴.

One of the most concerning species invasions in Scotland is that of the North American Eastern grey squirrel (*Sciurus carolinensis*) due to the risk it poses to the existence of the iconic red squirrel (*S. vulgaris*)⁵ and the destruction caused to native broadleaved woodland and commercial hardwood plantations⁶. The red squirrel is listed as a priority species in all Scottish Local Biodiversity Action Plans (LBAPs) for the local authority areas in which it is still present^{7, 8, 9, 10, 11, 12, 13, 14}, and many of these also mention the grey squirrel as an invasive species requiring targeted control^{7, 8, 10, 11, 12}. This briefing will discuss the invasive impact of the grey squirrel in Scotland and consider measures to mitigate this impact.

Red and grey squirrels

Between 1876 and 1929 the grey squirrel was introduced from eastern North America to over thirty sites in Britain. The species dispersed from its release sites and occupied areas of vacant red squirrel habitat during localised red declines, where it proliferated, preventing the recovery of red populations in these areas¹⁵. There are now at least 2.5 million grey squirrels in the UK and only 287,000 reds⁵, with greys having replaced reds in most of England and Wales and parts of Scotland¹⁵. It is widely accepted that, alongside habitat loss, the invasion of the grey squirrel is one of the main causes of the red squirrel's decline in the British Isles⁵.

Competition for food and habitat

Grey squirrels are larger, live in higher densities and can consume much greater quantities of food than reds. They are also able to digest young acorns before they are ripe enough for red squirrels to eat and will pilfer the cached food supplies of reds. This means that whenever they occur together in areas where there is overlap in their preferred food sources (i.e., in mixed or broadleaved woodland) the greys will outcompete the reds for food and tree sites, leading to lower red reproductive success and survival rates, eventually resulting in localised red extinctions¹⁵.

Squirrelpox virus

In addition to competitive pressure, the invasive grey squirrel further weakens red squirrel populations through cross-species transmission of the squirrelpox virus (SQPV). Grey squirrels brought SQPV with them from North America and have evolved immunity against the disease. Red squirrels, however, have no such

immunity and succumb to the disease in nearly 100% of cases. SQPV has been present in England for several decades, but only arrived in Scotland in 2005¹⁶. The virus is now prevalent in southern Scotland where monitoring and control measures are being employed to protect southern red squirrel populations and to inhibit the virus' spread northwards. The fear is that the virus will reach the red-only territory north of the Highland Line, thereby threatening to decimate the UK's core red squirrel population¹⁷.

Tree damage

Grey squirrels cause damage to young broadleaved trees by stripping their bark to get to the sugary sap below. This impedes the flow of water and nutrients to other parts of the tree, affecting size and growth form, and depending on the extent of the damage, can lead to tree death⁶. The annual cost of grey squirrel tree damage in England and Wales is estimated to be around £37m when lost timber value, reduced carbon capture, damage mitigation and replacement trees are taken into account¹⁸. It is, therefore, hardly surprising that the risk of losses due to grey squirrel damage was found to be one of the top deterrents to woodland creation by land managers¹⁹.

In addition to economic losses, there are also costs for climate change mitigation and biodiversity. When young trees are killed or their growth stunted, they are prevented from becoming the next generation of high canopy, biodiverse, veteran trees⁶. Promoting healthy, biodiverse native woodlands is essential for meeting Scotland's climate²⁰, biodiversity, and ecosystem restoration⁴ goals. The temperate rainforest on the West Coast of Scotland is currently the focus of concerted efforts to preserve and expand its coverage. Temperate rainforest is one of our most biodiverse ecosystems and is a globally rare and important habitat²¹. Allowing grey squirrels to expand their range into Scotland's rainforest zone could be catastrophic for the successful regeneration of this already very vulnerable ecosystem.

Tackling the invasion

Strategic grey squirrel control

The most effective defence we currently have against the relentless incursion of the grey squirrel in Scotland is humane culling. This is carried out through a combination of trap-and-dispatch and shooting methods which are largely targeted in four priority areas: Argyll, the Trossachs and Stirling; Tayside; North East Scotland; and South Scotland. The Saving Scotland's Red Squirrels (SSRS) partnership has been carrying out strategic grey squirrel control work since 2007, with the Scottish Wildlife Trust having taken on project staff contracts and most of the coordination of the project since 2009. Due to the Trust's position as a charitable organisation, the successful execution of strategic grey squirrel control in Scotland until now has relied on short-term, project-based funding. The work of SSRS to date has shown that grey squirrel control is an effective and necessary practice in the fight for the survival of the red squirrel in Scotland²². The Trust believes that it is now time for grey squirrel control work to be embedded in the operations of permanent institutions like statutory or publicly funded agencies to ensure long term, stable provision.

Pine marten

Encouragingly, it seems that our recovering native pine marten could become an important ally in the battle against grey squirrel incursion. Landscape-scale studies into the relationship between pine marten and grey/red squirrel abundance in Ireland and Scotland have found there to be a negative relationship between pine marten and grey squirrel numbers, and a positive relationship between pine marten and red squirrel numbers where the three species co-occur. The pine marten will predate both red and grey squirrels, but greys are larger, less agile, and less vigilant to the pine marten than reds, making them easier for the pine marten to catch. Having evolved alongside the pine marten, red squirrels are well adapted to avoid predation by it, and so have a considerable advantage over greys where pine martens are present. Pine

marten densities outside of the highlands are still low, however, and it is uncertain whether they will recover to densities sufficient to suppress grey squirrels across the grey squirrel's range. Given the high grey squirrel densities that exist in certain parts of Scotland, it is unlikely that pine marten predation will be able to completely replace human intervention, at least in the short-to-medium term. There is, however potential for this native predator to offer a sustainable long-term solution in the places that it recovers to suitable densities^{23, 24}.

Fertility control

The Animal and Plant Health Agency (APHA) are in the process of developing an oral contraceptive for grey squirrels as an alternative to culling²⁵. The contraceptive is still in the research and development phase and it will be several more years before it is approved for use. When and if it is approved, its viability for use in Scotland will hinge upon a species-specific delivery method being devised that is guaranteed to exclude native wildlife, particularly red squirrels and pine martens, from accessing the contraceptive-laced bait. The overlap in size between these native species and the grey squirrel means that the weight sensitive bait-hopper systems currently being trialled do not offer this guarantee. The system in its current form may allow the contraceptive to be administered to grey squirrel populations that do not co-occur with red squirrels and pine martens²⁵, in much of England, for example. However, the priority areas for grey squirrel control in Scotland are, by design, places where red and grey squirrels are likely to coincide and are also within, or near to, the pine marten's expanding range. Finding a practical, affordable solution to administering the contraceptive with complete exclusivity to the grey squirrel may still be a long way off. Until then, targeted grey squirrel control will continue to be the only feasible way to deal with grey squirrel incursion in Scotland.

Gene drives

Gene drives are a type of gene that have a higher-than-average rate of transmission to the next generation, and so can spread rapidly through a population²⁶. Wildlife geneticists are currently developing synthetic gene drives for use in invasive species management. This technique could be used to introduce genes for female infertility into targeted grey squirrel populations, offering a highly species specific, non-lethal method of control²⁷. This is, however a science in its infancy, with major societal and political challenges, and environmental risks associated with it that would need to be overcome before it could ever be introduced into wild populations²⁸.

Conclusion

The invasive non-native grey squirrel poses a serious threat to Scotland's native biodiversity, both directly, by driving the red squirrel towards extinction, and indirectly through the effect it has on native woodland regeneration and the economic viability of commercial broadleaved forestry. The disincentive to plant new broadleaved woodland because of the threat of tree damage could also serve to reduce Scotland's carbon sequestration capacity at a time when it is vital that this is maximised. Grey squirrel populations must be controlled, and their range expansion halted if we are to prevent their negative invasive effects from becoming any more widespread. Coordinated landscape-scale humane culling has been shown to be an effective grey squirrel control method and is currently all we have in our arsenal to keep this invasive species at bay. The recovery of the pine marten, the development of a contraceptive, and gene drives are all attractive alternatives to culling, however none of these are solutions to the immediate threat of grey squirrel incursion replacing one of our best loved native species and causing the degradation of some of our most important habitats. In this, the UN Decade on Ecosystem Restoration, Scotland has a responsibility to do everything in our power to reverse the depletion of nature by 2030. Ensuring long-term, stable provision of grey squirrel control will be an important part of achieving this.

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November 2022

1. Williams, F., Eschen, R., Harris, A., Djeddour, D., Pratt, C., Shaw, R. S., Varia, S., Lamontagne-Godwin, J., Thomas, S. E., and Murphey, S. T. (2010). *The Economic Cost of Invasive Non-Native Species on Great Britain*. CABI. CAB/001/09
2. Manchester, S. J. and Bullock, J. M. (2000). *The impacts of non-native species on UK biodiversity and the effectiveness of control*. Journal of Applied Ecology. **37**: 845 – 864
3. IPBES (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages.
4. The Scottish Government. (2013). *2020 Challenge for Scotland's Biodiversity*. Available at: [2020 Challenge for Scotland's Biodiversity - gov.scot \(www.gov.scot\)](https://www.gov.scot) (Accessed 29th August 2022)
5. UK Squirrel Accord. (2022). *Red squirrel conservation*. Available at: <https://squirrelaccord.uk/squirrels/red/> (Accessed 29th August 2022)
6. UK Squirrel Accord. (2022). *Tree Damage*. Available at: <https://squirrelaccord.uk/squirrels/tree-damage-by-greys/> (Accessed 29th August 2022)
7. Scottish Borders Council (2020). *Scottish Borders Local Biodiversity Action Plan 2018 – 2028*. Available at: Scottish Borders Council, Melrose.
8. Norman, P. (2009) *Dumfries and Galloway Local Biodiversity Action Plan*. Dumfries and Galloway Biodiversity Partnership.
9. Argyll and Bute Council. *Argyll and Bute Council's Biodiversity Strategy and Action Plan*. Argyll and Bute Council.
10. Loch Lomond and the Trossachs National Park Authority (2018) *Wild Park: National Park Biodiversity Action Programme 2018-2023*. Loch Lomond and the Trossachs National Park Authority.
11. Cosgrove, P. (2002) *Cairngorms Local Biodiversity Action Plan*. Cairngorms National Park Authority.
12. Tayside Biodiversity Partnership (2016) *Tayside Local Biodiversity Action Plan 2nd edition 2016 – 2026*. Tayside Biodiversity Partnership.
13. Highland Environment Forum (2021) *Highland Nature: Biodiversity Action Plan 2021 – 2026*. Highland Environment Forum.
14. Aberdeen City Council. *Nature Conservation Strategy*. Aberdeen City Council.
15. Russ, J. (2018). *The Red Squirrel Book*. Llanelli: Graffeg.
16. Tonkin, M. (2021). *Squirrelpox Detection in the Central Lowlands 2017-2020*. Saving Scotland's Red Squirrels Partnership Report.
17. Ewen, K. (2021). *Squirrelpox: Staying ahead of the spread*. Available at: <https://scottishsquirrels.org.uk/2021/03/31/squirrelpox-staying-ahead-of-the-spread/> (Accessed 8th September 2022)
18. Richardson, W., Jones, G., Glynn, M., and Watson, P. (2021). *An Analysis of the Cost of Grey Squirrel Damage to Woodland*. Prepared by RDI Associates Ltd for the Royal Forestry Society.
19. The Royal Forestry Society. (2020). *Woodland Creation Opportunities and Barriers – survey results 2020*. Available at: [Woodland Creation: Opportunities and Barriers - Royal Forestry Society \(rfs.org.uk\)](https://www.rfs.org.uk) (Accessed 8th September 2022)
20. The Scottish Government (2020) *Update to the Climate Change Plan 2018 – 2032 Securing a Green Recovery on a Path to Net Zero*. Available at: [Update to the Climate Change Plan 2018 - 2032: Securing a Green Recovery on a Path to Net Zero \(www.gov.scot\)](https://www.gov.scot) (Accessed 8th September 2022)
21. Alliance for Scotland's Rainforest. (2022). *Saving Scotland's Rainforest*. Available at: [Alliance for Scotland's Rainforest \(savingscotlandsrainforest.org.uk\)](https://savingscotlandsrainforest.org.uk) (Accessed: 5th September 2022)
22. Porton, G., McHenry, E., Nuttall, M., and Lambin, X. (2020) "Evaluation of the progress of Saving Scotland's Red Squirrels towards its region specific management aims, accounting for imperfect detection." University of Aberdeen, Saving Scotland's Red Squirrels and People's Trust for Endangered Species.
23. Sheehy, E. and Lawton, C. (2014). "Population crash in an invasive species following the recovery of a native predator: the case of the American grey squirrel and the European pine marten in Ireland". Biodiversity and Conservation. **23**: 753–774
24. Sheehy, E., Sutherland, C., O'Reilly, C., Lambin, X. (2018). "The enemy of my enemy is my friend: native pine marten recovery reverses the decline of the red squirrel by suppressing grey squirrel populations." Proc. R. Soc. B **285**: 20172603.
25. Beatham, S. (2021). APHA Science Blog: *How do you feed an oral contraceptive to 2.5 million grey squirrels?* Available at: <https://aphascience.blog.gov.uk/2022/01/21/grey-squirrel-contraceptive/> (Accessed 9th September 2022)

26. Whitelaw, B. and McFarlane, G. (2022) "*Accelerating Evolution*". The Biologist – Features. Available at: <https://thebiologist.rsb.org.uk/biologist-features/accelerating-evolution> (Accessed 15th September 2022)
27. Faber, N., McFarlane, G. R., Gaynor, R. C., Pocrnic, I., Whitelaw, C. B. A, and Gorjanc, G. (2021) Novel combination of CRISPR-based gene drives eliminates resistance and localises spread. *Nature: Scientific Reports*. **11**:3719
28. Hartley, S., Tatingfong, R., and Fidelman, P. (2022) "*The principles driving gene drives for conservation.*" *Environmental Science and Policy*. **135**: 36-45