Simulating the return of Scottish lynx

Failures surrounding the reintroduction of large carnivores like the Eurasian lynx are common and costly - simulations may offer a solution

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Eurasian lynx are realistic candidates for a British reintroduction
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REINTRODUCING the Eurasian lynx (*Lynx lynx*) to Scotland is an idea that has been gaining traction in recent years. However, before the species can be brought back, we must decide where to put them. Simulating reintroductions beforehand can guide this decision.

The extinction of species in their native ranges is another ugly symptom of the damage that humanity is doing to the natural world, with their loss perhaps epitomising just how detrimental humans can be to biodiversity. But it's not all doom and gloom, as in certain cases where a species is lost but its habitat remains, the species can be brought back. The process by which this is done is reintroduction.

Unfortunately, reintroductions often fail, with estimates in a study by Jule et al. (2008) suggesting that success rates may range from 11% to 53%. When this is paired with the high financial costs of reintroduction schemes, it becomes clear that the process of reintroduction needs to be made more efficient. More effective planning is an option for boosting this efficiency.

Reference: Jule, K.R., Leaver, L.A. and Lea, S.E., 2008. The effects of captive experience on reintroduction survival in carnivores: a review and analysis. Biological conservation, 141(2), pp.355-363.

Simulating reintroductions through computer models represents one way to improve the effectiveness of planning. By inputting real-world data into these models, we can, in essence, reintroduce a species without actually reintroducing it. The simulations these models create can closely mimic real-world reintroductions at a fairly low cost and be used to forecast the success of a potential reintroduction, thus indicating the suitability of a potential location and creating a valuable tool for planning.

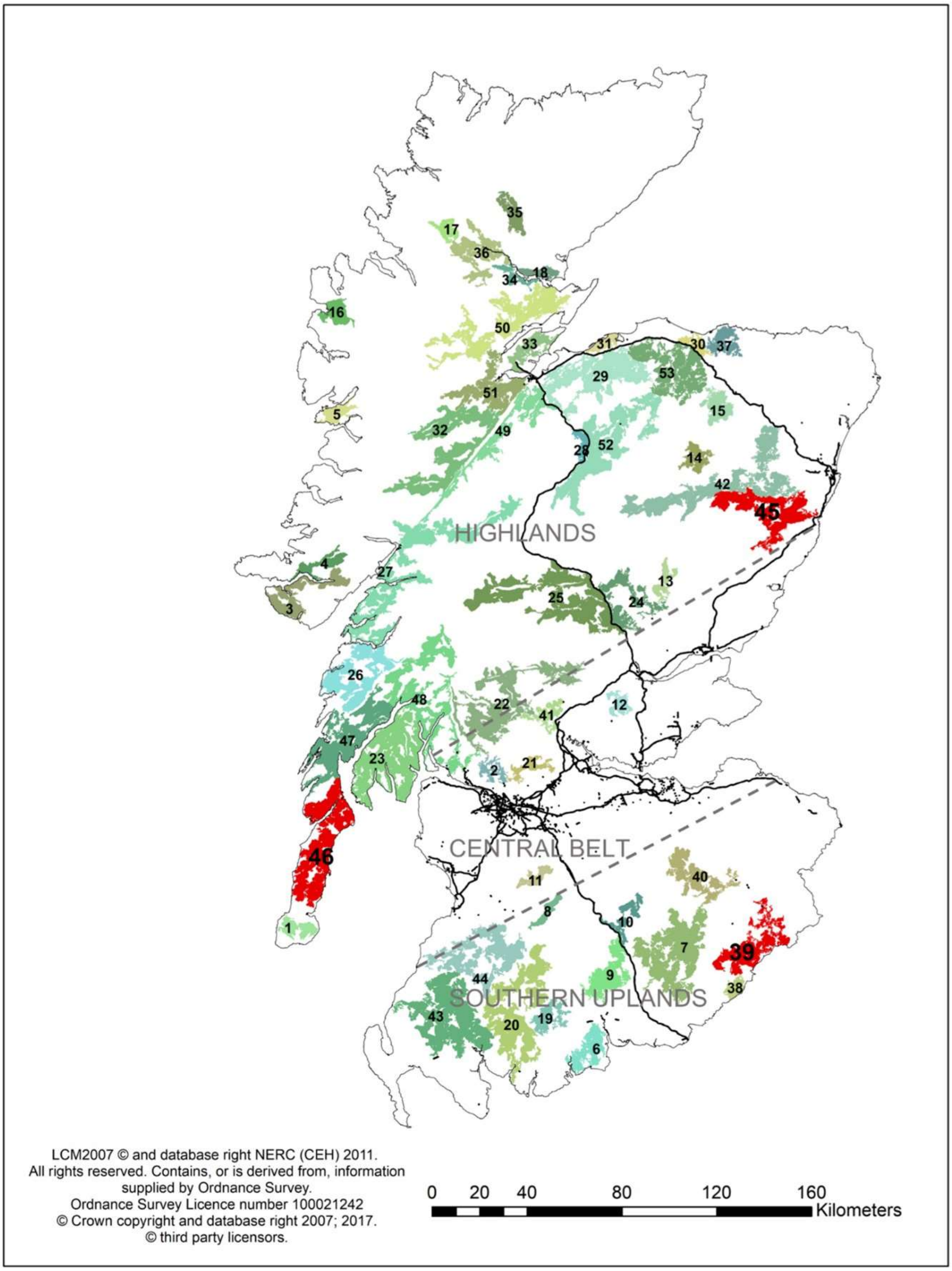
Ovenden et al. (2019) put this idea into practice by simulating the reintroduction of Eurasian lynx into three different Scottish sites using "individual-based models" and observing how their populations fared over time.

Why lynx and why Scotland?

It's easy to forget that Eurasian lynx are native to Great Britain. Their 1200-year, overhunting-induced hiatus has led to the lynx being largely forgotten as a component of the nation's ecosystems. Lately, though, this has changed, with improved understanding of the ecological importance of apex predators and a growing interest in rewilding among conservationists causing the lynx's absence to be viewed with more scrutiny. This culminated in the proposal of a British lynx reintroduction, which, if socio-economic disputes are overcome, can be considered a very realistic prospect.

If a British lynx reintroduction scheme is to become a reality, a decision about where they should be reintroduced to will need to be made. Scotland seems like an ideal candidate and was the last place the lynx lived until their eventual extinction. Since then, suitable habitat for the species has lived on in the region, with three sites considered especially promising. The first of these is the Kintyre peninsula; the second is Aberdeenshire; and the third is

Kielder Forest. Identifying the best of these three sites is a and realistic goal for a modelling approach and may have conservational utility in the future.



Three sites (shown in red) look especially promising for lynx: The Kintyre Peninsula (46), Aberdeenshire (45), and Kielder Forest (39).

Ovenden et al. (2019)/ScienceDirect

It's also worth noting that lynx reintroductions aren't a new concept. Europe alone has already seen 15 attempts to bring the species back to separate sites, although, as summarised by Linnell et al. (2009), only five of these attempts were successful. Regardless of their success, however, they all provided useful real-world data. This data can be inputted into models to increase the accuracy of the simulations they produce, which can then be used to plan more effective future reintroductions, hopefully with a better success rate than 5/15.

Reference: Linnell, J.D., Breitenmoser, U., Breitenmoser-Würsten, C., Odden, J. and von Arx, M., 2009. Recovery of Eurasian lynx in Europe: what part has reintroduction played. Reintroduction of top-order predators, pp.72-91.

The availability of this real-world data and the realistic prospects for future application made the Scottish lynx reintroduction an ideal subject for Ovenden et al. (2019)'s simulations.

What is an individual-based model?

Individual-based models are a type of computer model that can be used to simulate how a population of animals disperses through and settles in a new environment. As the name suggests, individual animals are simulated separately and will disperse and survive relative to their surrounding environment and the other individuals within it.

The model that Ovenden et al. (2019) used considered three important factors regarding reintroduction: 1) the local variation in habitat types; 2) the uncertainty in how an animal navigates its landscape; and 3) the fact that the process of dispersal consists of three separate stages. By considering these factors, a representation of the real world can be built and used for assessing the suitability of a site for reintroduction.

Habitat-types simply describe the type of habitat present in a certain place (e.g., woodland, grassland, etc.) and are rarely uniformly distributed. To account for this, a cost grid can be used. A cost grid is a simple, two-dimensional grid made up of equally sized, individual cells, with each cell assigned a specific habitat type. These habitat types are associated with specific cost values and mortality chances per step. "Cost value" describes the energetic cost an individual will pay to enter a cell of a certain habitat type, while "mortality chance per step" describes the likelihood of an individual perishing when it passes into a cell of a given habitat type. Lynx are more likely to avoid cells with higher cost values and are more likely to die in cells with higher mortality chances.

In Ovenden et al. (2019)'s model, the cells within the cost grid were 100 m x 100 m, and a land cover map was used to define their respective habitat types.

With the landscape of the site defined by a cost grid, how individuals move across it needs to be addressed. In the real world, animals do have an idea of what the best path for them to take is, which leads to them avoiding more costly habitat types. However, their ability to select the best path is limited by their own perception. They can only see, smell, and hear so far; the habitat beyond this range is a mystery to them. This leads to uncertainty in the direction of their movement and the selection of inefficient pathways in the real world. A lot of the decisions animals make also have no clear basis, which adds a degree of randomness to their movement.

Ovenden et al. (2019) accounted for the uncertainty and randomness of an individual's movement by using a "stochastic movement simulator". This is an algorithm within the model that simulates the movement of individuals across the cost grid depending on the cost value of the habitat types that an individual may move into and the perceptual range of that individual, while also accounting for random decision-making. When dispersal data from real lynx is used to set these parameters, an accurate representation of their movement can be achieved.

Another important fact about dispersal is that there's more to it than just movement. In fact, dispersal is considered a three-phase process. The first of these phases is emigration, where an individual initially begins to move away from a given location, which in this context is the site of reintroduction. This is then followed by the transfer phase, which describes the process by which an individual moves across the landscape, which is represented here by the cost grid. When the transfer phase ends, the settlement phase begins, where an individual stops its movement and settles into its own patch, with "patch" describing a cluster of grid cells of an ideal habitat type.

The transfer phase in Ovenden et al. (2019)'s model is accounted for by the stochastic movement simulator operating over the cost grid. But the transitions between phases also need to be modelled. This is done in accordance with dispersal patterns observed in real-world lynx and is dependent on factors such as the density of individuals nearby and their sexes and ages. For example, males will only enter the settlement phase if a nearby mature female is present to mate with.

So, where do we put them?

Once the model was established, real-world data from past reintroductions was inputted, and 100 simulations were run for the Kintyre peninsula, Aberdeenshire, and Kielder Forest. Of these, the clear winner and most suitable site for reintroduction was the Kintyre peninsula, which excelled in every metric of success considered.

The first of these metrics was how many times, out of the 100 simulations at each site, the population survived until its hundredth year. Here, Kintyre stood head and shoulders above the rest, with 83 populations surviving until year 100. Aberdeenshire placed second, with 35 populations lasting until year 100, and Kielder was third, with a meagre 21 populations lasting the century.

Another metric considered was the average number of individuals present in the hundredth year at each site. Kintyre excelled once more, with an average of 150 individuals. And yet again, Aberdeenshire was second, with an average of 98 individuals, while Kielder fell in last place with 55 individuals.

The distance that the reintroduced populations were able to spread was also used to gauge success and was quantified by taking the average number of patches (groups of grid cells containing suitable habitat) occupied in the hundredth year of the simulations at each site. Again, Kintyre was favoured, with an average of 27 lynx-occupied patches formed by the hundredth year, while Aberdeenshire produced 19, and Kielder produced 10.

From the insight provided by these simulations, the message is clear. If we are going to reintroduce lynx to one of these sites, we should choose the Kintyre peninsula, and until changes to the habitat in Kielder occur, it probably shouldn’t be considered for lynx reintroduction at all.

Modelling approaches like these are likely to prove massively helpful in the future due to how quickly and cheaply they can be run while still providing valuable insight into the suitability of a location for reintroduction. They also have use far beyond the lynx, with potential application in the reintroductions of a range of species. Perhaps they’ll even see further use in Scotland — there’s been a buzz rising around wolf reintroductions lately.

Reference: Ovenden, T.S., Palmer, S.C., Travis, J.M. and Healey, J.R., 2019. Improving reintroduction success in large carnivores through individual-based modelling: How to reintroduce Eurasian lynx (Lynx lynx) to Scotland. Biological Conservation, 234, pp.140-153.

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