Flying Squirrel LIFE, LIFE17/NAT/FI/000469

Report on monitoring the conservation actions in the Flying Squirrel LIFE project

Action D1, Monitoring the conservation actions

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Pictured is a glimpse of a search event for signs of the flying squirrel (photo by Anni Koskela).

Droppings of this nocturnal and silent species can be found at the bases of large trees, especially in spring. Cavities made by woodpeckers in the trunk of aspen or twig dens made by red squirrels in sheltered spruces serve as preferred nesting places.

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Content

Introduction

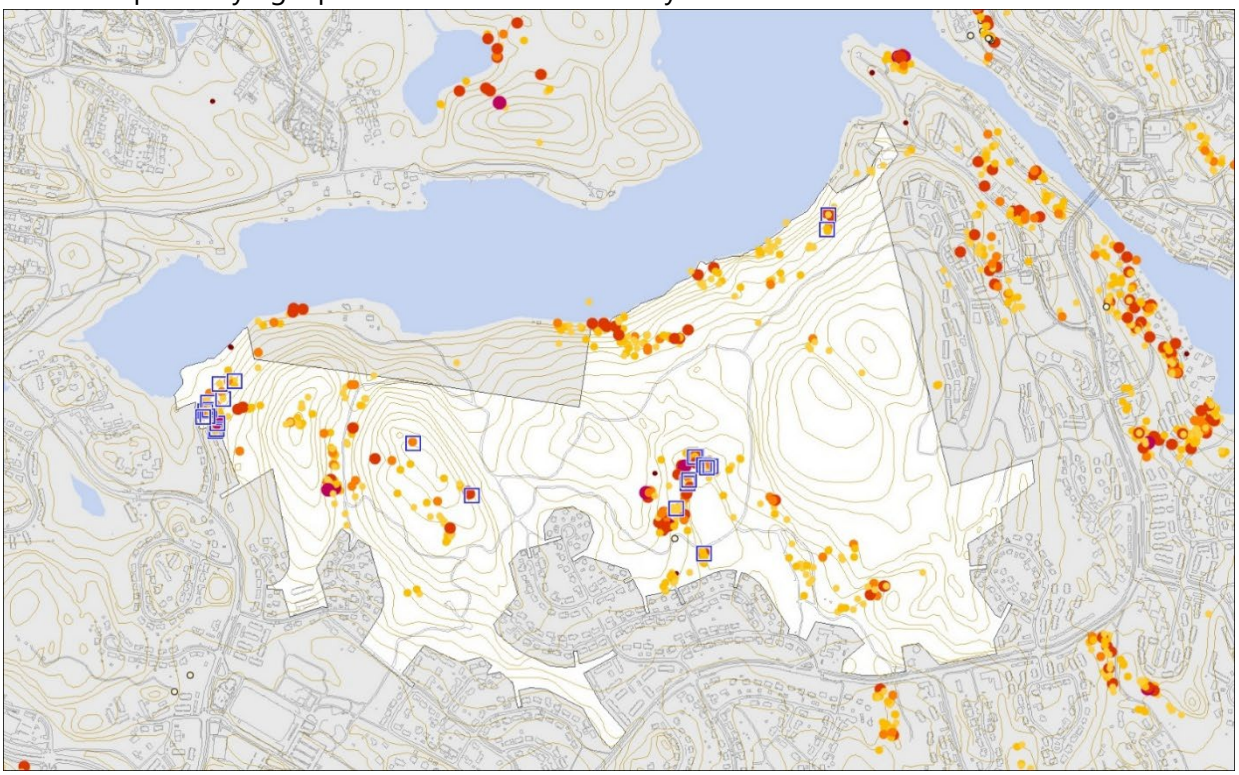
In this summary, the main findings of monitoring conservation results at project sites in the Flying Squirrel LIFE project are shown. The aim of monitoring Action D1 was to evaluate the effects of conservation actions C1-C4 at project sites. The goal of conservation actions was to improve habitat networks in urban areas (Actions A5-C1), maintain habitat networks in managed forests (Actions A6-C2), improve continuity of aspen in the long term (Actions A8-C3), and improve the survival of the flying squirrel in the short term by increasing the number of safe nesting places with nest boxes (Actions A9-C4).

Project sites have been selected for reaching effective concrete conservation actions, with an aim to do management that maintains important habitat characters or improves their condition for the future.

More information and locations of project sites are shown in summaries of project sites with related actions (see References) and can be found on the project's website under respective action codes.

With monitoring, we evaluate whether the management actions have been useful steps in the sometimes-long process to improve habitat availability for the flying squirrel in Finland and Estonia. Depending on the activity, monitoring has included flying squirrel inventories in forests and the use of nest boxes, but also checking the survival of planted trees, regeneration of aspen shoots as well as condition of fences.

A fluctuating pattern is often seen in the occurrence of flying squirrels. The flying squirrel is a relatively short-aged species (the average reached age being about two years) and adults are resident at their relatively large home ranges using many separate nests the year round. Thus, it may be that after a resident individual passes away, it takes some time until the next generation finds the habitat.
A true example of flying squirrel occurrence over the years is illustrated in Picture 1 below.



Picture 1. Example of the variation in the flying squirrel occurrence in the City of Kuopio during the project years 2019-2024 at Jynkänvuori area (project site in white). In a common pellet search method, droppings of the flying squirrel are searched under large trees in spring. The darker orange the dot on a map, the more droppings were found at the spot: all observations during 2019-2024 are combined. Blue squares show the findings from spring 2022, when there were only few observations. If an inventory had been made only once, and just on that year, most of the areas often used by the flying squirrel would have been unnoticed. (Map: Kalle Ruokolainen, the City of Kuopio, 2025)

Monitoring flying squirrel forests and potential forests in the neighborhood over many years is thus very important to understand the underlying pattern better in the region. If a flying squirrel inventory is made only once, other often or seldom used parts of forests may not be noticed, even though they may be very important parts of the local habitat network. If in these cases “empty” forests are heavily managed, the habitat loss is evident.

There are also many underlying patterns such as weather conditions, diseases, parasites, and predators which can affect the occurrence of flying squirrels. As these variables were not investigated in the project, reasoning behind the observations remains open.

D1.1. Urban project sites: Action chain A5-C1-D1

The aim of this action chain A5-C1 was to support the continuity of habitat networks in urban areas as best practices in Finland (Deliverable A5, 2025). In urban areas, habitat patches for the Flying squirrel are often small and distances between them are long and risky, which may cause isolation problems.

Once built areas are permanently off-limits for dispersal of the flying squirrel. There are often many man-made wide gaps such as roads, railways, electric channels and open areas. Therefore, instead of deciding what trees can be cut down in managed forests, in urban areas we may have to consider how to build a continuity of the habitat network by planting new trees to broken corridors.

Urban forests are typically used in complex ways and for a wide range of visitors, and protecting the flying squirrel inside city boundaries involves many different land-use specialists and interest groups.

Overall, cities must balance between the needs of urban sustainable growth in the long term and the viability of the flying squirrel population. With different goals for land use, conflicts in the planning process and land ownership are unavoidable.

Unexpected findings of the flying squirrel are unwanted situations. The cities would benefit from knowledge of a sound ecological habitat network and improvement actions, if they make land use managers’ work easier in predicting the presence of the flying squirrel. In the long run, a sound habitat network can also adapt to metapopulation dynamics as well as changes in the flying squirrel density.

Here, different solutions were executed to improve survival of the flying squirrel in urban ecosystems with 21 project sites in cities of Espoo, Jyväskylä and Kuopio (Table 1).

All these cities have strong flying squirrel populations and long experience in taking care of the species at their central city areas. They also have long experience in combining goals for the flying squirrel conservation and other land use. All activities aim to sustain functional habitat networks within the increasing pressure of growing city structure in the future.

Table 1. Improvements of flying squirrel habitats in urban project sites at cities of Espoo, Jyväskylä and Kuopio.

City	Project site	Moving connection	Conservation & recreation	Nest boxes	Aspen continuity
ESPOO	Latokaskenniitty	5 plantings			
ESPOO	Suvisilta	1 planting			
ESPOO	Hyljelahti		1 area		
ESPOO	Finnoonlaakso	1 planting & 8 jumping poles			
JYVASKYLA	Jyskänvuori			5	
JYVASKYLA	Ylistönmäki			4	
JYVASKYLA	Kotalamminmäki			3	
JYVASKYLA	Jääskelä			8	
JYVASKYLA	Kangasvuori			4	
JYVASKYLA	Halssilanmäki			1	
JYVASKYLA	Seminaarinmäki			2	
JYVASKYLA	Tikanväylä	1 planting & 31 jumping poles			
KUOPIO	Puijo (N2000)			9	230 aspen seedlings
KUOPIO	Kolmisoppi-Neulamäki (N2000)			9	
KUOPIO	Etelä-Kuopion lehdot ja lammet (N2000)			15	
KUOPIO	Korsunmäki ja Keinälänniemi (N2000)			9	
KUOPIO	Pirtti & Pirtti läntinen (questionnaires for citizen used)		1 area	15	
KUOPIO	Jynkänvuori (questionnaires for citizen used)		1 area	15	
KUOPIO	Rantapuistonkatu	1 planting			
KUOPIO	Keinänlahti	1 planting			
KUOPIO	Kattilanmäenkatu	1 thinning			

New moving connections

Monitoring focused on the condition of planted trees and watering of the young trees in every city. In general, the survival of planted trees has been good. Some dead trees were found but they were replaced. Condition of jumping poles in Espoo and Jyväskylä was followed, and so far, no damage or violence was observed in them. Based on droppings, flying squirrels were observed to use forests next to all these areas where seedlings were planted.

However, as the planted seedlings are about 2 meters high, they cannot yet be used by flying squirrels for gliding. Thus, no efforts to study if flying squirrel individuals use these new planted trees or poles were yet done. Monitoring the use of connections becomes possible when trees have grown some more meters. Results of the new moving connections planted can probably be seen in next ten years. As shelter and canopy cover seem to be important for flying squirrels to move, we can expect that the individuals will learn to use these connections in the future.

The long-term continuity of important habitat characteristics was improved by planting young trees for new moving connections. This was done in 7 project sites, including 11 new green corridors altogether. Jumping poles were installed on two of these sites as they may offer moving possibilities for flying squirrels before young trees grow high enough. Monitoring and taking care of the trees and poles will be continued after the project by the cities responsible. Young trees representing various species were used as they would adapt better to new growing conditions in a new place than older trees would. They will also reach the preferred height from the flying squirrel's perspective (ca 10 m) within a few years after the project.

The flying squirrel needs trees of at least ten meters height for successful glides from tree to tree, and thus a gap between single trees should not preferably exceed 20 metres. Planting young trees next to existing streets or parks puts high demands on them. Each city selected variable tree species, which would most probably survive at each location. Trees had to be specifically trained in tree nurseries to survive in a new, stressful environment close to traffic and pedestrians, and for the first two years before their actual rooting they needed extra maintenance with continuous care and watering.

Espoo

In Latokaski, over 120 trees were planted in autumn 2021 in places that had fragmented or very narrow canopies. The trees were planted especially in crossings of pedestrian routes and car roads, and close to power lines. Most of the trees were deciduous trees but also spruces and pines were planted. Setting different tree species also created a chance in forming new flying squirrel habitats. In Suvisilta, almost 40 trees were planted in 2021 on both sides of Länsiväylä, the highway crossing through flying squirrel area. When these trees grow high enough, they will strengthen the faint connections that existed before. In Finnoonlaakso, the Länsiväylä highway crosses flying squirrel habitat the same way as in Suvisilta. Before the project, there had not been a connection over Länsiväylä for the flying squirrel, but Finnoonlaakso is an important link between the shore of southern Espoo and Espoo central park. A new connection was created in autumn 2022, when over 300 trees were planted. Eight artificial jumping poles were erected in places where tree planting was not possible.

Kuopio

New moving connections by planting young trees were planned on sites Rantapuistonkatu, Keinänlahti and Kattilanmäenkatu. After all, in Kattilanmäenkatu no new plantings were needed: new young deciduous trees had grown naturally on this spot already, so the only procedure was light thinning that allowed more growing space for chosen trees at the spot.

Jyväskylä

In late 2023, new moving connection was developed in Tikanväylä, a highway that crosses flying squirrel habitat areas with a powerline going alongside the highway. In addition to planting trees, 31 artificial jumping poles were set up on spots where the highway or powerline prevents tree planting.

Aspen continuity

Monitoring focused on condition of the seedlings and their coverings in Puijo area, city of Kuopio. The survival of saplings was monitored annually from 2021 to 2024. Monitoring showed that most of the seedlings survived in 2020-2023. Winter 2024 was very hard on vegetation in Kuopio area and a lot of small trees, bushes and plants died. Seedlings planted in 2020 survived the harsh winter (2024) better than seedlings planted in 2022. It is likely the older seedlings were better adapted to the site, but also the actual planting site could have been better in 2020 than in 2022.

The aim was to improve flying squirrel habitat network and promote aspen continuity in long-term by planting aspen seedlings in the area. Aspen saplings were planted at Puijo Natura 2000 site: close to the Puijo tower (Puijo I) and a related Pieni-Valkeinen area (Puijo II). Aspen is a key species for the flying squirrel, offering leaves for food and cavities for nests. Before woodpeckers can make safe cavities into an aspen, the tree must be mature and thick enough, which takes decades. Forests in Puijo are mainly spruce-dominated with lack of deciduous trees, also of aspen. The natural regeneration of deciduous trees in the middle of a spruce dominated forest is also low and uncertain.

Aspen saplings were planted in an area of 1.8 ha in two phases. During summer 2020, 150 aspen saplings were planted in three small openings (150-1000 m^2) and during autumn 2022, 80 more were planted. Coverings for seedlings (“fence tubes” or “mesh-covers”) were used to prevent herbivory. The planting areas were already existing small open areas within the forest, so there was no need to cut down any trees. The survival of saplings was monitored annually from 2021 to 2024.

Monitoring in summer 2023

Puijo I (nearby Puijo tower): Most of the saplings stayed alive in 2020–2023. In 2021 there were 2 dead saplings, and in 2022, 7 dead ones. In summer 2023 11 dead saplings were found and 7 in bad condition/barely alive. Other saplings looked well, but they grew quite slowly and some of them were still quite small. It is probable that there is not quite enough sunlight for them here.

Puijo II (in Pieni-Valkeinen): Most of the saplings survived alive in 2020-2023. In 2021 and 2022, all saplings were alive and in summer 2023 only 1 dead and 1 barely alive sapling was found. A tree

had fallen on 2 of the saplings and their coverings were twisted, yet the saplings had remained alive. Other saplings looked good, and they had grown better and higher than the saplings in Puijo I area. In mesh-coverings, some branches had grown through the mesh.

Monitoring in summer 2024

Puijo I: 52 alive, 68 dead, 8 in bad condition (128 saplings altogether). Older saplings (planted in 2020) seem to have survived better than the younger ones planted in 2022. One possible reason for this is age: younger saplings have had less time to put down roots and grow. Older saplings were also planted in the best areas and therefore they have a better growth place. Younger saplings got less light and grew more poorly.

Puijo II (Pieni-Valkeinen): 97 alive, 4 dead, 1 in bad condition (102 saplings altogether). In this area the saplings survived better and grew bigger. Here the saplings were planted in a bigger opening and therefore they got more sunlight. Their growth place is located lower and is possibly more sheltered than the growth place in the Puijo slope.

Combining flying squirrel conservation and recreation values

Monitoring forestry practices included flying squirrel inventory based on a common pellet search, condition of the forest after measures and possible storm damage checks regularly in 2020-2024. In Kuopio, questionnaires for residents before and after the activities were also done (Kuopion kaupunki 2021, Rantama 2024). There were three project sites where combination of flying squirrel conservation and human recreation were planned and carried out: Hyljelahti in Espoo, and Pirtti Läntinen and Jynkänvuori in Kuopio.

Monitoring showed that in all three areas, flying squirrels were present after the forestry measures were carried out. The quality of the remaining habitats in urban forestry areas was found as expected, and no storms or other damage were reported.

In Hyljelahti, Espoo, forestry measures were executed in 2021 and 2022 with an aim to combine the flying squirrel conservation and recreation use (Ahopelto et al. 2022). The aim was to secure safe recreation use and retain the forest as a quality environment for the flying squirrel. The whole Hyljelahti project area is a good flying squirrel environment, and there are 5 core habitats in it. Monitoring was done in spring 2023, and droppings were found under trees with holes. Therefore, it can be drawn that forest measures on these areas have not been unfavorable for the presence of the flying squirrel.

In Kuopio, flying squirrel monitoring covered larger areas in 2019-2024. In Pirtti Läntinen, flying squirrel has been present in 2019-2023, but in 2024, no droppings were found. In Jynkänvuori, flying squirrel has been present every year in 2019-2024. It seems unlikely that forestry measures done in 2021 would have affected the flying squirrel presence. In Natura 2000 sites (Puijo, Kolmisoppi-Neulamäki, Korsunmäki-Keinälänniemi, Etelä-Kuopion lehdot ja lammet) the pellet search method was executed in 2019, 2029, 2021 and 2023.

The city of Kuopio has also developed “a pellet index” based on the numbers of droppings found (Ruokolainen 2025), which is demonstrated for two areas in Figure 1. In Pirttiniemi, there were less

droppings in 2021, and hardly any in 2022-2024. On the other hand, in Jynkänvuori area there were less droppings in general but more variation between years.

More information on monitoring older urban areas can be found from the summary for project action A4 (Hakala et al. 2022). For this study, previous city plan sites and their surroundings were checked for occurrence of the flying squirrel during 2019-2020 in Kuopio and Jyväskylä, and in Espoo also in 2021.

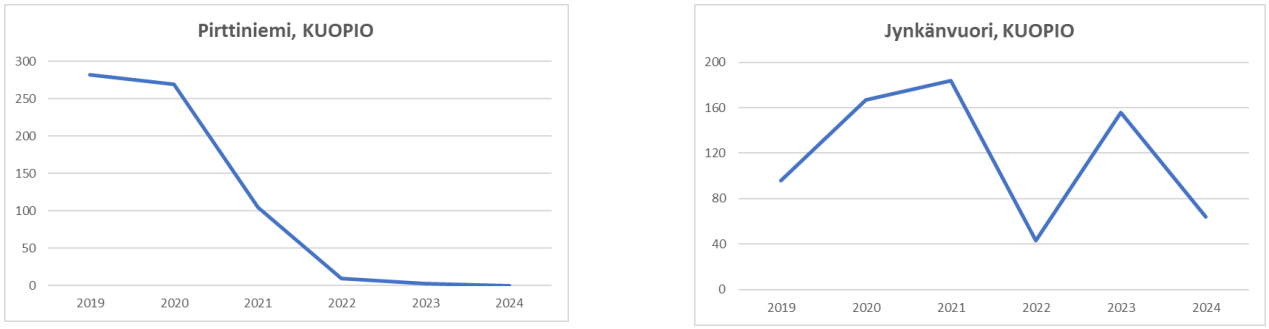


Figure 1. "A Pellet index" describes the occurrence of flying squirrel droppings across years in Pirttiniemi and Jynkänvuori in the city of Kuopio during the project. In Pirttiniemi (left), the index decreased rapidly during 2021-2022 and remained low after that. In Jynkänvuori (right), the index had lower values than Pirttiniemi and varied between years 2019-2024.

Recreation values of urban forests: perspectives of residents

In Kuopio, residents living close to Pirttiniemi and Jynkänvuori sites were participated: their wishes for the area development as well as their attitudes for combining conservation and recreational values were surveyed twice during the project, in 2019 and in 2024 (Kuopion kaupunki 2021, Rantama 2024).

Urban forests are also part of citizens' recreation areas. This creates certain requirements for the maintenance of these forests, such as safety and landscape features, but also for general approval. Forestry plans for careful harvesting were made so that both goals could be reached. Whereas flying squirrels typically prefer a mixture of deciduous trees and a multilayered forest structure, humans often appreciate open views over the landscape, as well as thinning the forest close to the roads.

With selective cuttings and adjusting tree species composition with a long-term perspective, the habitat network for the flying squirrel would be maintained and on the other hand, city planning can continue in other stands not being so important for the flying squirrel.

The aim is that the requirements of both flying squirrels and recreation will be met. The forest cuttings, plantings of young trees and new walking routes for citizens were carefully planned and carried out. For Jynkänvuori area, there are no plans for future buildings. It is also hoped for that Pirtti läntinen stays as a popular recreation area. The purpose of the cuttings was to support the pine dominance in areas planned for buildings within the next 20 years.

The aim in Jynkänvuori and in Pirttiniemi forest management plans was to harmonize the habitat requirements of the flying squirrel with the wishes of recreational users and residents as effectively as possible. Different factors were emphasized in various areas. For instance, in the most critical

areas of the flying squirrel habitats, known as core areas, only actions that do not degrade the flying squirrel's habitat could be undertaken.

Flying squirrel pellet survey from spring 2019 and older observations were used when planning forestry actions. Other nature values in the area were considered as well. The wishes of recreational users were considered in the vicinity of paths and routes, and residents' wishes were considered near houses. Forestry actions were classified into three main categories: improvements to potential flying squirrel habitats, improvements to recreational use by humans and scenery and forestry actions.

In the second survey made in 2024, most participants did not consider the protection of the flying squirrel had caused them any inconvenience. The few reasons given for conflict were, for example, the postponing of city plans, not being able to cut down unwanted trees on the property or in proximity, and the untidiness of the surrounding forests. The importance of nature as a source of wellbeing and the appreciation of urban forests as part of the community structure was well represented in the given answers.

General estimation of the success of action

Monitoring of the actions showed that flying squirrels were found at sites also after the activities. These observations encourage to continue careful planning of variety of tasks which can improve habitat availability and connectivity in urban areas. However, it is essential to keep in mind the importance of monitoring the effects during a longer period, to see the effectiveness and functionality of the solutions.

Cities are constantly developing, and land use planners need to foresee upcoming development pressures even decades onward. Cities will benefit from the definition of a sound habitat network for the flying squirrel. Even with expensive improvements, it would be worth the cost, as it would make predicting the flying squirrel occurrence easier (Ahopelto et al. 2021). Unexpected findings of the occurrence of the flying squirrel are unwanted situations as they result in laborious work in new planning processes. A sound habitat network has a high ecological quality, especially when it can adapt to a changing population size and density within a long-time frame.

Definition of a habitat network beforehand is essential, as suitable habitat patches in urban areas are often small with long distances between them. Habitat networks for the flying squirrel in urban forests should be maintained in a way that allows safe recreational use, as public open space and green areas are often limited. This way attitudes towards flying squirrel and species conservation will probably stay more positive.

Nest boxes

Monitoring of the 96 nest boxes focused on their use by flying squirrels. The use of a box was estimated with an endoscope to view inside the box, and by searching for droppings on its roof. In Jyväskylä, the nest boxes were monitored yearly in 2021 and 2022, whereas in Kuopio, the nest boxes were monitored yearly from 2020 to 2024 instead of only three years planned (Table 2). In Kuopio, the occupancy of nest boxes was monitored by visiting each box regularly in 2020-2024,

twice a year (Ruokolainen 2025). The first monitoring visit was in early or mid-May, when flying squirrel pups are already born but still in the nest. The second monitoring visit was at the beginning of July, to gather information about possible second litters.

The availability of safe nesting places was improved by setting new nest boxes in Jyväskylä and Kuopio, on 13 sites altogether. In Jyväskylä, 27 nest boxes were put up in 7 sites. In Kuopio, 72 nest boxes were put up in 6 sites in 2019 and 2020, and 3 boxes to 1 site in 2021. In Kuopio, 3 different box types were tested and in Jyväskylä, one box type was used. There were two goals: to increase nesting places for flying squirrels in urban forests and compare different nest box types. In urban areas it is seldom possible to expand the existing habitats for the flying squirrel, but the habitat quality can be improved by increasing the availability of safe nesting places by nest boxes. Flying squirrels are known to approve nest boxes quite well in Finland, so this is the fastest way to support survival of individuals and the quality of the habitat network.

Monitoring showed that in Jyväskylä, flying squirrels found the nest boxes quickly. Already in the following year after the boxes were set up, many boxes were found to have a nesting individual. On the other hand, boxes were not very popular in Kuopio. In total, only a small fraction of the nest boxes was used by flying squirrels (Table 2). There was not much difference between a robust timber box with a thick front wall and a drilled "cylinder" in a log box. Interestingly, the boxes with holes in the bottom were clearly the least favored by the flying squirrels, with little to no sight of flying squirrels in Kuopio. FS seemed to prefer some nest boxes more than others and moved between nest boxes inside the same project area. The condition of the boxes remained good, and no damage to them was noticed.

Table 2. Flying squirrel occupancy per all nest boxes in site during monitoring years in Jyväskylä (green) and in Kuopio (blue) in the project.

Observations of FS in the nest boxes	**2020**	**2021**	**2022**	**2023**	**2024**
Jyskänvuori	-	3/5	4/5	-	-
Ylistönmäki	-	1/4	1/4	-	-
Kotalamminmäki	-	1/3	1/3	-	-
Jääskelä	-	2/8	3/8	-	-
Kangasvuori	-	3/4	0/4	-	-
Halssilanmäki	-	0/1	0/1	-	-
Seminaarinmäki	-	0/2	0/2	-	-
Puijo (N2000)	0/9	0/9	0/9	1/9	0/9
Kolmisoppi-Neulamäki (N2000)	0/9	0/9	0/9	0/9	0/9
Etelä-Kuopion lehdot ja lammet (N2000)	0/15	1/15	1/15	1/15	1/15
Korsunmäki ja Keinälänniemi (N2000)	0/9	1/9	0/9	0/9	0/9
Pirtti & Pirtti läntinen	1/15	0/15	0/15	0/15	0/15
Jynkänvuori	3/15	3/15	3/15	2/15	0/15

Lessons learnt

As a general estimation, the conservation actions in urban areas have been successful as all planned activities were executed, and no harmful effects were observed in monitoring.

The usefulness of nest boxes for the species did not seem straight-forward and thus safeguarding habitat for flying squirrels should be the priority. We aimed to increase safe nesting places with nest boxes for the species, as nest boxes for flying squirrels are often even recommended in urban areas where forestry measures are carried out. The actual use of the boxes was not necessarily high, although the monitoring period during the project was limited and flying squirrels may start using them later when they get used to new boxes. Continuous monitoring may result in more information in time: years are different and there are many risks for the survival of flying squirrels, such as weather conditions and food supply, diseases, parasites, and predation. Indeed, a camera by the Kuopio Museum of Natural History in the project witnessed that an ermine (*Mustela erminea*) destroyed a whole flying squirrel litter in the blink of an eye. To our knowledge, this was the first evidence that an ermine preys also in nest boxes in urban areas.

Green corridors will increase tree canopy coverage in time but unfortunately, no solid results that flying squirrels use the corridors have yet been received. The usefulness of building new moving connections by planting young trees is a way to increase structural connectivity in the landscape. When trees have grown a bit more to give more shelter and height to glides, there perhaps can be practical ways to investigate actual use of them. So far, no results have been received from various tries of different game cameras. Indeed, Suvisilta bridge in Espoo is close to a place where a flying squirrel individual with a radiotelemetry collar crossed the wide Länsiväylä highway (Yrjölä et al. 2021). It is possible that the individual could have used a pedestrian bridge, but no suitable method has yet been found to verify the crossings. Furthermore, nature detection dogs visited the sites of Jyväskylä in 2024 (Action A2), but they did not locate any results which could be interpreted as solid signs of flying squirrels using recently built green corridors. The effectiveness of green corridors in enhancing flying squirrel movement remains open but can likely be seen later.

We can recommend using questionnaires as a part of planning processes. Combining conservation and recreation goals in urban forest areas is an important aspect in urban planning, where questionnaires for citizens give very much information from the social sustainability perspective.

D1.2. Managed forests: Action chain A6-C2-D1

In Finland, there were two separate approaches to maintain flying squirrel habitat network in managed forests. The first one focused to a set of forests within the range of the flying squirrel in Finland, where a joint planning process was used as a demonstration of a good practice for a complicated planning task. Project site plans are reported separately to private sites (Deliverable A6, 2025a) and to state-owned sites (Deliverable A6, 2025b). The second approach focused only to the region of Rekijokilaakso Natura 2000 area in Southwest Finland (Deliverable A6, 2025c), where careful forest planning was improved to maintain and improve the connectivity the valuable river valley being a local center for high biodiversity values.

In Estonia, two kinds of conservation activities were planned (Deliverable A6, 2025d). First, flying squirrel friendly forest management was planned outside strict protection sites for mainly limited management zones to combine strict conservation with goals of the landowner. Second, as a novel approach, 2 green corridors were planted across a wide electrical powerline to support connectivity in the fragmented landscape.

In Action A6, site plans were made. In Action C2, the selected management measures were executed. In Finland, one option in C2 was also "no management", sometimes even official protection using a permanent protection ("YSA") or a temporal protection via METSO program was used. In Action D1, the effects of C2 were monitored.

Finland, A6 Forest plans with a joint planning process

Monitoring managed forest sites included a flying squirrel inventory with a common pellet search method. No other field measurements were taken. Monitoring was targeted at the sites in question and often also at the neighborhood of sites. Monitoring was done annually in spring during the project (2019-2024), with only a few exceptions. After the project, monitoring will be done regularly at relevant inventories: on private lands, the responsibility is on the landowners and on the state-owned lands, on MHFORESTRY (Metsähallitus Forestry ltd). Observations of the flying squirrel remain in national species databases (such as Laji.fi) and will be considered according to the nature conservation legislation in the future.

Flying squirrel occurrence varied at sites (see details below), but no storm damages were observed.

A joint planning process was demonstrated to make 37 forest plans to private and state-owned sites. Most of them, 35, were managed in action C2 during the project. Two private-owned site plans were not executed yet but it is likely the owners will execute the plans after the project. Project sites in Finland, which belonged to action chain A6-C2 were inventoried annually with only a few exceptions. The baseline inventory (A6) using a common pellet search method was carried out in the spring 2019 or in 2020, and on two additional sites in 2021. Baseline inventory was done by experts in FS inventory: by FANC in 2019-2020 and by an entrepreneur in 2021.

Monitoring inventories using the pellet search method in spring (D1) were carried out by personnel of SMK (the Finnish Forest Centre) in private sites, and by personnel of MHPWF (Metsähallitus Parks & Wildlife Finland) on state-owned sites. FS monitoring was also done annually in a state-owned site Pata-aho, where accidental cuttings were done in fall 2018. Most of the people doing monitoring gained education for FS inventory during the project, so their experience was lower than those people making baseline inventories. FS occupancy was monitored at the site in question, and in some cases, also in its neighboring forests within 1-2 kilometers.

Results

In this report, we present summaries of monitoring observations, and no monitoring details are shown for separate project sites. As there was no follow up of other potential factors, reasons behind the observed patterns remain open. Further analyses of the monitoring data gathered will be carried out later in co-operation with researchers from universities to understand better the

observed patterns. The results for a state-owned site Pata-aho are included (cuttings in Pata-aho were accidentally done in fall 2018 without the joint planning process, but FS occupancy was monitored annually after that).

As a whole and as expected, we observed variation in the FS occupancy pattern. In all, we see that during the first spring, in 2019, there were more occupied sites observed (83 %) than in other years (33-45 %) (Table 3).

This pattern may partly be due to the inventory skills of people. For example, a person with less experience does not necessarily notice single droppings or may miss "untypical" trees which should be checked. On the other hand, unexperienced people may do extremely careful work when the observation of no droppings is true.

Table 3. Number of occupied sites per year in a group of 37 project sites including 27 private sites and 10 state-owned sites (monitoring results of a state-owned site Pata-aho are included in this summary, although it was removed from the A6-C2 chain). Baseline inventory was done to all sites, but monitoring inventory was sometimes missing from 2021 and 2022.

	Baseline inventory 2019-2020	Monitoring 2021	Monitoring 2022	Monitoring 2023	Monitoring 2024
Number of inventoried sites	37	33	36	37	37
Occupied sites	31	15	12	16	14
% of sites occupied	83,8	45,5	33,3	43,2	37,8

As we know, years differ. In the urban areas of Kuopio and Jyväskylä, located about in the middle of Finland, there were less findings of FS than usual during the years 2023 and 2024. However, we cannot see differences between the years in this set of project sites which were scattered in the range of the FS in Finland.

When we focus on the sites where no forestry measures were carried out during the project, i.e., the management option was volunteer conservation or no management based on an A6 plan for the site was yet done, we also see this variability (Table 4). In this set of ten sites, including both private and state-owned sites scattered in Finland, a similar variation in the occurrence pattern is seen. All these sites were observed to be occupied in the baseline inventory, but after that, the occurrence varied from always occupied to sometimes occupied up to always empty during the follow-up period.

Table 4. Observations of flying squirrel occupancy at project sites where no management with cutting was carried out (10 sites: private & state-owned): a site was either protected, or no forestry decisions were made (based on plan A6). Inventory was done in spring using a pellet search method: 1 = occupied as droppings were found, 0 = empty as no droppings were found, x = no inventory.

Baseline	Monitoring			
2019/ 2020	2021	2022	2023	2024
1	1	1	1	1
1	0	x	1	1
1	x	0	1	1
1	0	1	0	1
1	0	0	1	0
1	1	0	0	0
1	0	0	0	0
1	0	0	0	0
1	0	0	0	0
1	x	0	0	0

As we know, flying squirrels move well in forests and may utilize many hectares as their home ranges. Thus, an individual may use a larger area than a focal project site, or on the other hand, several individuals may use habitats which are located close to each other. We collected monitoring data from state-owned forests from the focal stands but also from neighboring habitats found within 1-2 km distance around them. There were also existing forested connections between habitats, so that neighbor forests were potentially reachable by flying squirrels (Table 5). Management C2 according to plans made in Action A6 was mainly done in winter 2021 or 2022, before the monitoring in spring. No forestry measures were done in Hanhivaara and Jänisselkä whereas in Pata-aho, cuttings were done in 2018. All sites locate in Kainuu-Koillismaa region.

Table 5. Flying squirrel occupancy in state-owned project sites (10, Pata-aho included) and in their neighboring sites. For each project site, 1-3 neighboring sites within 1-2 of kilometers of the focal site were monitored. If any of the neighbors were occupied, a neighbor received a status for occupied. Inventory was done in spring using a pellet search method: 1 = occupied as droppings were found, 0 = empty as no droppings were found, x = no inventory. Careful cuttings (C2) were done in 2021 or 2022 except to Hikilehto and Jänisselkä; cuttings in Pata-aho were done in 2018.

Project site	Baseline 2019	2021	2021 Neighbor	2022	2022 Neighbor	2023	2023 Neighbor	2024	2024 Neighbor
Pöppölä	1	x	x	1	1	1	1	1	x
Sipilänperä	1	1	1	0	1	0	0	0	1
Kurikkavaara	1	1	1	1	1	1	1	1	x
Palovaara	1	1	1	0	1	0	1	0	1
Parviaissuo	0	0	x	0	1	0	0	0	1
Hanhivaara	1	0	1	1	1	0	0	1	0
Hikilehto	0	0	0	0	1	0	0	0	0
Jänisselkä	1	1	x	0	0	0	0	0	x
Kivilampi	1	1	1	1	1	1	1	1	x
Pata-aho	1	1	1	0	1	1	0	0	x

For many project sites, habitats in the close neighborhood seemed to be used as well by flying squirrels (Table 5). Sometimes a focal project site was not occupied, but its neighbor was. These observations indicate that there are flying squirrels around using available habitats. Anyway, occurrences in project sites and in their neighborhood varied over the years. This highlights the importance of maintaining available habitats, but also continuous monitoring to understand the habitat use better in time. Unfortunately, we have monitoring data from neighboring habitats only from a few private project sites, which cannot be used for estimating occupancy effects in the close network of habitats.

The years when the management activity was executed differed. As a result, the number of monitoring years after the management was sometimes low. This was the reason to carry out annual FS inventory before the management at most private sites: to reach as many years of monitoring data as possible during 2019-2024 (in state-owned sites, the management was done mainly in 2021).

When we focus on the FS occupancy pattern before and after careful cuttings (planned in Action A6), we also see variation in the occurrence (Picture 2). At 16 managed sites, FS was observed present also after the management at least once. At seven (7) sites, FS was observed before management but not after that. At four (4) sites, there were no recent observations of FS before and after. In these sites, the management plan was done as if the species were present.

We present the monitoring data only in this format, and do not offer detailed site data in public. This is partly due to agreements with private landowners (some sites are sensitive), but also to ensure that we can continue to further analysis with researchers. We will not even compare the observations plainly against the size of project sites, as it would oversimplify the situation as there is a large variation in sizes. We also know that the quality of surroundings is an important factor in explaining occupancy of the flying squirrel: occupancy in consecutive years may be linked to larger areas or to the location of a site close to other suitable forests. Despite realizing this, we do not have thorough data on forests around sites nor resources to carry out analyses during the project. This kind of data set covering many years offers a possibility to run high-quality habitat and landscape scale analyses afterwards to find at least some possible underlying factors for the observed occupancy pattern.

	1	1	Cuttings	1	1	1			
	1	1	Cuttings	1	1	1			
1	1	1	Cuttings	1	1				
1	1	1	Cuttings	1	1				
		1	Cuttings	1	1	1	1		
		1	Cuttings	1	1	1	1		
	1	x	Cuttings	1	1	1			
			Cuttings	1	1	1	1	1	1
0	1	0	Cuttings	1	1				
		1	Cuttings	1	1	1	0		
		1	Cuttings	0	1	0	0		
	1	0	Cuttings	0	0	1			
	1	0	Cuttings	0	1	0	0		
		1	Cuttings	1	0	0	0		
		1	Cuttings	1	0	0	1		
		0	Cuttings	1	1	1	0		
		1	Cuttings	0	0	0			
	1	0	Cuttings	0	0	0	0		
		1	Cuttings	0	0	0	0		
		1	Cuttings	x	0	0	0		
		1	Cuttings	0	0	0			
1	0	0	Cuttings	0	0				
	1	1	Cuttings	0	0	0	0		
		0	Cuttings	0	0	0			
	0	0	Cuttings	0	0	0	0		
		0	Cuttings	0	0	0	0		
		0	Cuttings	0	0	0			

Picture 2. Observations of flying squirrel occupancy at project sites in relation to forest management (27 sites including both private and state-owned sites): data shown from baseline inventory 2019/2020 to the last monitoring year 2024 in relation to the cutting event (based on the site plan made in Action A6). Inventory was done in spring using a pellet search method: 1 = occupied as droppings were found, 0 = empty as no droppings were found, x = no inventory.

Discussion

Monitoring of the flying squirrel occupancy during 2019-2024 shows variation in the site occupancy (tables 3, 4 & 5 and picture 2). It seems that some project sites were always occupied whereas in majority of the sites, the situation varied. Some sites became empty after cuttings, but at some sites management did not seem to be correlated with timing of the management.

There can be many reasons behind this occupancy pattern, but as we do not have a thorough study of possibly affecting factors, we cannot speculate further. The gathered data will be further analyzed with scientific approaches.

There are many perspectives to be considered when trying to understand the patterns better:

Inventory effect. There is a striking difference in the percentage of occupied sites showing over 83% occupancy at the baseline inventory (years 2019-2020) but decreasing to about half, 33-45%, during monitoring years (2022-2024). Baseline inventory was done by experts of flying squirrel inventory, whereas monitoring inventories were carried out by newly educated personnel. More experienced persons are likely able to notice even very small traces of the species leading to a status of an occupied site: for example, just a single dropping leads to a category "occupied" of a site.

On the other hand, less experienced people may be extra careful, and their observations of zero traces of the flying squirrel can also be true. Furthermore, at some sites, people doing monitoring did notice flying squirrel droppings at neighboring forests but not necessarily at the focal project site. As we did not evaluate the skills of people, we cannot say.

Timing of the inventory. Monitoring was done in spring as it is known to be the best time for noticing droppings of the flying squirrel. Field work started in Southern Finland in the end of March, and in the Northern parts of the country, inventories ended in early June. It is unlikely that the timing had a major effect on the observations.

Year. The number of occupied sites varied between years, but it was not clear that certain years would have less flying squirrel observations in these data sets. It is noteworthy, that in urban sites (C1) in cities of Jyväskylä and Kuopio, during the years 2023-2024 there were less observations of the flying squirrels than in previous years (Table 2, Ruokolainen 2025), and year 2024 was very harsh in Kuopio. Many large-scale factors such as weather conditions and food availability may also be applied in further analysis.

Biological reasons. Adult flying squirrels are resident and perhaps tolerate some changes in their home range before leaving their familiar places and searching for new nesting places. However, as the average life span of a flying squirrel is short, about two years, it is possible that when a resident adult has died, a young individual has not yet settled at a site. Or resident flying squirrels having very large home ranges might not have used the project site at the time of the inventory but used neighboring habitats instead. However, we did not follow individuals' space-use year-round. In addition, possible underlying situations with predator pressure, parasites, or diseases possibly affecting the life span or habitat selection, were not gathered during monitoring years.

Disturbance and/or habitat loss. Resident individuals may have searched for other forests after forestry measures, even though forest management was planned carefully to maintain suitable habitat for the flying squirrel. Joint planning, for example on the sites in action A6, was made in co-operation with many experts with help of nature conservation authorities (Hurme et al. 2023).

As a conclusion, it is impossible to draw conclusions of the reasons behind the observed patterns as simultaneous monitoring of other factors were not done. Based on the findings, the importance of continuous monitoring is highlighted, with the education of people making baseline inventories and monitoring in forests. As fluctuating occupancy pattern seems to be typical for flying squirrels, it is important to use expertise to monitor forests for some years before making any decisions of their use (Picture 1).

In addition, forest data and predictive models may help to estimate the quality of the forests for the flying squirrel. Earlier, for example, Hurme et al. (2008) showed that the quality of habitat patches can be linked to the observed occupancy pattern in them. Always occupied patches are more often larger and have more suitable habitat in their neighborhood as well as forest connections between forests than patches which are seldom occupied. Furthermore, habitat patches designed of poor quality do not necessarily get occupied at all.

A predictive map layer illustrating potential habitats for the flying squirrel, built in the Flying Squirrel LIFE project, can be downloaded from laji.fi (laji.fi/about/5922) or from Paikkatietoikkuna (kartta.paikkatietoikkuna.fi/). Predictive habitat maps can be used to estimate local habitat networks and direct field inventories to potential parts of forests as a part of the land-use planning processes.

Finland, A6 Rekijokilaakso

In Finland, the river valley Rekijokilaakso and a Natura 2000 area therein (FI0200102) was used to apply landscape planning approach safeguarding the network of flying squirrel habitats and forested moving connections between them.

The purpose of this activity was to the landowners discuss together with professionals from authorities in conservation law (VARELY) and forestry law (SMK), and exchange knowledge. The authorities informed the landowners about the specialty of the Rekijokilaakso river valley, and the importance of careful forest planning related to the flying squirrel and other nature values. In total, 20 site plans were prepared for private estates together (Deliverable A6, 2025c).

The site plans have been handled on to landowners who will execute them after the project as they see suitable, but not as a part of the Flying Squirrel LIFE project. As there was no C2 action in Rekijokilaakso, no monitoring (D1) was carried out in the project. So far, agreements to establish permanent protection areas already cover over 150 hectares.

Estonia, A6 Forest plans

There was a delay in making management plans due to official procedures at the beginning of the project. After general delineations of conservation authorities on how to deal with flying squirrel breeding sites and resting places as well as in limited management zones were ready, the project work started. As a result, A6 forest plans were made to 31 private lands (Deliverable A6, 2025d). Of these, careful forest management according to A6 plans at 15 sites were executed in action C2. As a result, there was not much time to carry out monitoring activities after the C2 activities during the project. The landowners will be responsible for the management of their sites after the project.

Monitoring showed that at all the 15 managed C2 sites, there were no sites where the occupancy of a site was changed after the forestry measures had been carried out. This suggests that activities planned in the limited management zones were careful enough. Flying squirrel inventories will be continued after the project at relevant intervals. Monitoring of project sites was carried out by FS inventory experts of Keskkonnaamet (Estonian Environmental Board, EEB).

Estonia, A6 Moving connections

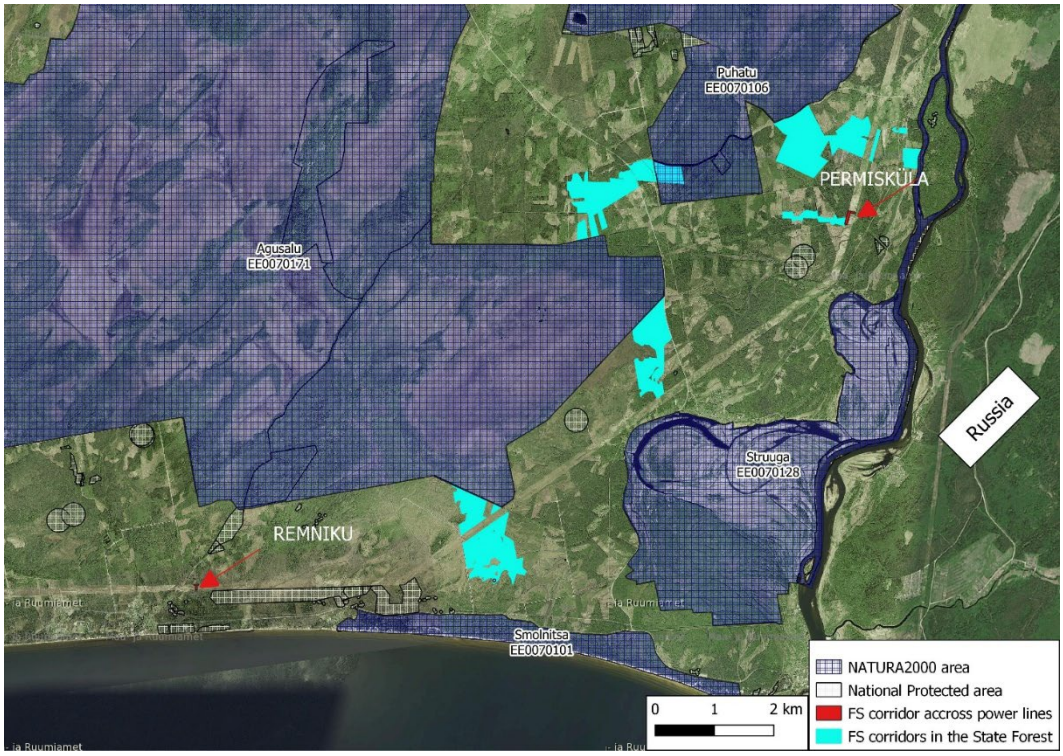
As an additional task, new moving corridors under wide electric powerline were built to improve habitat connectivity in the fragmented landscape in North-East Estonia in 2024 (Picture 3). Forested connections created by planting young trees will form a passage across an open area between habitats and are likely helpful for flying squirrels but also for other forest species (Deliverable A6, 2025d).

This novel task was applied first time in Estonia and agreed with a company Elering ltd and Riigimetsa majandamise keskus (State Forest Management Centre of Estonia, RMK), the responsible of the state-owned forests in Estonia. The possibility of building green corridors across electrical powerlines is an example of innovative thinking with a novel decision from the electrical company Elering ltd.

Project sites Remniku ja Permisküla at state-owned land on possession of RMK were planned and executed in 2024. Planting seedlings was done by the RMK staff. As planting was done in the last year of the project, there was no time to carry out proper D1 monitoring after the C2 activity.

In autumn 2024 both sites were visited, and seedlings were growing well a couple of months after planting. Only a few seedlings had died or were eaten by herbivores. Thus, the start of the new moving corridors looks promising.

After the project, monitoring of the green corridors will be carried out by RMK. RMK will also ensure that the planted trees and bushes remain within the height agreed with the electrical company Elering ltd. Although all planted seedlings represented native species likely reaching the accepted heights, they will be cut when needed. Info tables have been put to sites, and the electrical company is well informed to avoid any accidental cuttings. A method to monitor movements of the flying squirrels via the corridors will be investigated. Forested connections may naturally help other forest species along the flying squirrel.



Picture 3. Locations of Remniku and Permisküla sites where green corridors were planted across electrical powerline (Riigimetsa Majandamise Keskus).

Lessons learnt

We highlight the need to better understand the **importance of monitoring FS occupancy over the years**. It would be good to follow the forest area for some years to understand how local flying squirrels use it. Besides mostly used parts, in time it would be possible to notice also those parts of forests which are only seldomly used.

In this project, only one year for a baseline inventory of the FS was made. This was due to the limited period: every action from making the site plans (A&), executing (C2) and monitoring (D1) them was to be included within six years. Even though potentially important parts of the forests were also spotted in FS inventories and considered well in planning, and the forestry measures planned were mostly more careful than usual, the time scale remained rather short. With better understanding of the use of local forests over a longer time span, the quality of planning would have been even better.

In addition, considering neighboring forests and forested moving connections between them in FS inventory or monitoring can be recommended. A better understanding of the surroundings of focal forests can lead to **better consideration of the network of forested habitats** connected to each other by forested areas. With these kinds of landscape scale approaches, various databases and GIS techniques may play a big role in illustrating the potential of available habitats and moving connections between them. In addition, predictive habitat models built in the project (A3) may give support for large scale planning.

Electrical powerlines are typically wide, up to 100 meters or more, and being kept open to remain as such, they create potential moving barriers to any species preferring a shelter in higher vegetation, but especially to forest related species avoiding open areas. Thus, an agreement to create **green corridors** across wide open powerlines by planting native trees and bushes really is a novel action. As planted seedlings seemed to settle well, the start of having new green corridors for wildlife is promising.

Finally, applying **joint planning approach** as acknowledging the expertise of various professionals, as well as **discussions** with landowners to exchange knowledge and increase acceptance for conservation are encouraged. Experiences within the project showed that taking time to discuss is worth using. When time is spent well with complex decision making, as flying squirrel situations sometimes are, more sustainable solutions may be found. All these can lead to better consideration of the FS and other biodiversity values. This likely leads to better quality forest habitats for the species, which in time may result in more often occupied forests.

D1.3. Aspen continuity: Action chain A8-C3-D1

The goal of this action is to minimize habitat loss and fragmentation in the long-term, as trembling aspen (*Populus tremula* L.) is an essential character within the suitable habitats for the flying squirrel. Aspen provides preferred nesting cavities and buds, catkins, and leaves for food. It is also designated as a key species for biodiversity in boreal forests. However, many protected areas may have almost only a few old aspen trees left, which could disappear soon due to natural forest succession. Aspen has had problems during past decades mostly related to socioeconomic aspects; it has not had economic value but rather been considered a threat to the economically important pine (*Pinus sylvestris*), as a semi-host for the fungus pine-twisting rust (*Melampsora pinitorqua*). Therefore, aspens have been heavily destroyed in managed forests in certain areas. Nowadays herbivores and rodents prevent natural aspen regeneration by eating their seedlings.

In this action, the continuity of aspen was aimed to be supported in Finland at 16 state-owned sites (Deliverable A8 2025). This set of project sites included ten Natura 2000 areas (MHPWF), and six multiple-used forests (MHFORESTRY) close to conservation areas to support the network of the Natura 2000 areas. All action A8 project sites are located on state-owned land, and MHPWF has been responsible for monitoring them during the project.

Growing space for aspen was opened by different measures (Table 6). These included forestry measures, exposing mineral soil, fencing the aspen seedlings, and restoration burnings, depending on the site. Open space is essential in supporting aspen growth, for its natural life cycle usually starts after some disturbance in the forest such as forest fires: aspen is a fast-growing pioneer species settling in new, open sites. Often different measures were applied in same sites. All nature management activities were done outside important areas for the flying squirrel (such as breeding sites and resting places, feeding areas, or moving connections), and their timing was outside the flying squirrel's breeding season.

Table 6. Methods used to open growing space in project sites (Deliverable A8 2025) and monitoring observations therein during the project.

	Opening growing space by removing conifers	**Opening growing space by exposing mineral soil**	**Opening growing space by carrying out restoration burning**	**Protecting young aspens from herbivory, enclosures (pcs)**	**Supporting the aspen continuity with forestry measures**
Syöte (1)	x				
Riuskanselkonen (2)		x		12	
Huuhkajanlehto (3)	x	x		10	
Ulvinsalo (4)			Not finished		
Ison Jänisjärven lehto ja letto (5)	x				
Konnevesi-Kalaja-Niinivuori (6)	x				
Aurejärvi (7)	x				
Katajaneva-Vuorilammin alue-Huhtalampi (8)	x				

Haapasuo-Syysniemi-Rutajärvi-Kivijärvi (9)	x				
Palstonvuori-Jääskelä (10)	x				
Kivilampi (11)				5	x
Hanhivaara (12)				4	
Jänisselkä (13)				5	
Pata-aho (14)				5	
Kurikkavaara (15)					x
Palovaara (16)				5	x

Before starting the more detailed management plans, a baseline inventory for aspens was done on the project sites. Within Natura 2000 sites, no nature management was planned to any existing Natura 2000 habitat type, and flying squirrel inventory was done only at the Konnevesi-Kalaja-Niinivuori project site, where species data needed updating.

In managed forest sites, flying squirrel inventories were done within the planning process of A6. On Jänisselkä, Hanhivaara and Kivilampi project sites, activities were planned on enlargement of the project sites. This decision was made because the support for the aspen continuity seemed to be most relevantly done just outside the original project sites, which were mainly older boreal forests. The aspen continuity support measures in action C3 were designed to suit best to the conditions at each site.

After the project, MHPWF is responsible for monitoring the Natura 2000 area sites and MHFORESTRY for multiple-use forest sites. The success of aspen regeneration (vegetative shoots) and the condition of the fences will be checked annually to ensure that they remain in good condition and do not cause any harm to wildlife.

Opening growing space by forestry measures

Spruces or other trees around aspens or aspen groups were removed by using harvesters, chainsaws, or brush cutters to give more growing space for aspens. Removing pine and spruce was done at 8 Natura 2000 areas: Syöte, Huuhkajanlehto, Ison Jänisjärven lehto ja letto, Konnevesi-Kalaja-Niinivuori, Aurejärvi, Katajaneva-Vuorilammen alue-Huhtalampi, Haapasuo-Syysniemi-Rutajärvi-Kivijärvi, and Palstonvuori-Jääskelä.

The forestry measures were also done in 5 state-owned managed forest sites. At Kurikkavaara, Palovaara and Kivilampi, selective cuttings and small gap fellings were used close to large aspens to enhance regeneration of them. In Hanhivaara, Jänisselkä and Kivilampi, the thinnings of young forests were done within the enlargements of project sites, as it was seen as a more efficient location to promote future aspen growth. In Pata-aho, the forest cuttings were accidentally done in autumn 2018, and no more forestry measures were carried out there. Aspens were left standing in all cuttings, and growing space for aspens was opened with selective cuttings and small gap fellings. Aspens had been selected as retention trees, but some of the densest aspen groups were thinned to allow the remaining aspens to grow bigger. Skillful forestry workers were the key people in this.

Monitoring showed that the condition of the forests at sites after careful cuttings remained as planned. No storm damage was observed. Regeneration of aspen had started, although the stems were often eaten due to herbivory pressure if they were not inside the enclosures. FS occupancy at managed forest sites is reported in detail in a section "D1, Finland, A6 Forest plans with a joint planning process". Occupancy of FS in project sites varied between the years, although all forestry measures were carried out outside the most important parts of the forests for the FS.

Opening growing space by exposing mineral soil

Exposing mineral soil was done at 2 Natura 2000 sites, the Riuskanselkonen and Huuhkajanlehto project sites. Mineral soil was treated with excavator. An experiment with a terracut cultivator was also done, but unfortunately, it was not efficient enough for this measure. Treatment areas were immediately fenced to prevent herbivory of seedlings.

Monitoring showed that in openings made by excavator, the regeneration of aspen had started. As the herbivory pressure is relatively high in these regions, only those saplings which were inside enclosures had survived.

Opening growing space by restoration burning

Restoration burning was planned for the Ulvinsalo Natura 2000 site. Preparatory work -such as opening the fire corridors- was done as planned, but unfortunately burnings could not be executed due to unlucky weather conditions in summers of 2023 and 2024. In addition, the Ulvinsalo site even turned challenging to physically reach, due to the changed world situation: after the Russian invasion to Ukraine in 2022, Finland tightened the security of its Eastern border. Monitoring was not carried out as no burning was done.

Protecting young aspens with enclosures

Protecting young aspens from herbivory with enclosures was done at 5 managed forest sites, at Kivilampi, Hanhivaara, Jänisselkä, Pata-aho and Palovaara. At Kurikkavaara, there were naturally so much aspen growing that enclosures were not needed. At 2 sites in Natura 2000 areas, enclosures were used at Huuhkajanlehto and Riuskanselkonen.

The number of enclosures was planned to be 70 altogether but ended up being 46. This was mainly due to higher material costs, but also because more optimal fencing was reached with a bit smaller enclosure number. Some of the fence elements were broken during transportation, and a few were even stolen from a temporal storage close to the forest in question. The size of the enclosures varied from 18 m^2 to 50m^2, the largest being 1.2 hectares. Fence elements reserved for Ulvinsalo site were installed to Riuskanselkonen site in autumn 2023, to a single large enclosure of 1.2 ha in size.

Monitoring showed that the condition of enclosures had remained surprisingly good over two winters. Only very small repairments were needed. The regeneration of aspen has started well, and

after two years, the saplings were almost one meter high within the enclosures in 2024. Young aspens were eaten outside the enclosures, which indicates continuous herbivory pressure. So far, differences between small and large enclosures have not yet been recognized. The enclosures will remain in place for at least 10-15 years, until aspens have grown high enough to avoid herbivores. After that the enclosures will be used for similar conservation purposes elsewhere.

Lessons learnt

The methods used to support aspen continuity aimed to open growing space for this pioneer tree species. Sometimes it may seem contradictory to use forestry measures or breaking the ground cover for nature conservation purposes, but to mimic disturbances in nature to some extent, it can be useful.

With novel approaches, learning takes some time with trials and errors. For example, we noticed that a terracut cultivator breaking the ground cover for exposing mineral soil was too soft tool for the purpose. We also learned that with careful forestry methods, such as selective cuttings and small gap fellings, but especially with removing trees around large aspens, foresters were too careful at first. At some sites additional work was needed to achieve the preferred outcome. Naturally, being very careful with a new task is a good solution as it is always possible to go again and take some more measures than to deal with overly heavy practices after which the past forest cannot be brought back again.

The final effects from this action for the flying squirrel will be seen within a long-time scale of tens of years. The already promising growth of young aspens may lead to success in the future. The fences will be reused for similar conservation purposes after 10-15 years, when the aspens have grown tall enough to avoid the herbivory during thick snow cover in winter.

The enclosures used in this project are relatively small, so more efficiency for larger areas may need to be developed. In addition, further development of durable fence elements, and a comparison with other methods (e.g., larger areas with different fences, moose ribbon, and changes in herbivory species populations) including monitoring their effects, are likely needed.

D1.4. Nest boxes: Action chain A9-C4-D1

In Estonia, in early 2010s', it was found out that Estonian flying squirrels are not well adapted to nest boxes (of the ca 100 boxes set up, only around 10 % were used and mainly as hiding places, but not for breeding). As the flying squirrels in Finland seem to accept many kinds of nest boxes also for breeding, the project offered a chance to test the potential of nest boxes on a larger scale: by adding many boxes, we hoped to increase the interest of Estonian flying squirrels to get used to and even start breeding in them.

In the Flying Squirrel LIFE project, 250 nesting boxes were placed for supporting the habitat networks and nesting sites in Northeastern Estonia (A9, A map for nest box locations. Sensitive annex for final report). The locations of the nesting boxes were decided based on the habitat connectivity modelling (Deliverable A3, 2023) combined with field inventory. The boxes were

placed in suitable forest patches mainly in 2021 within a territory covering ca 7000 km^2, located in Natura 2000 areas and state-owned land (Picture 4). The nest boxes were placed particularly along movement corridors between habitat patches, to support connectivity in the fragmented landscape. It was also hoped that they would guide the individuals to the protected areas on state-owned lands. The boxes were first set up in dispersal corridors and later mostly to the key occurrence sites of the flying squirrel.

Picture 4. A map showing regions where 250 nest boxes were installed to offer safe nesting places along potentially moving corridors. Location information is sensitive, as all flying squirrel data in Estonia. The nest boxes will likely also improve the connectivity of the habitat network in a fragmented landscape of North-East Estonia. (Map: Estonian Environmental Board)

Monitoring was executed by visiting each nest box annually, either in spring or autumn, during the project until 2024. The nest boxes were surveyed by climbing up to the box and peeping in, to check for nesting material. In addition, trail cameras were used to follow up the potential visits in boxes. Monitoring the nest boxes will also be continued after the project at relevant intervals.

Monitoring showed that nest boxes were not often used by flying squirrels in Estonia. No breeding in them was observed. On the other hand, especially wasps (Vespidae sp.) and great tits (*Parus major*) have been observed using the nest boxes. The use of the boxes is documented in detail to the CINEA with a sensitive report, as flying squirrel information in Estonia is not open (a sensitive annex is delivered to the CINEA).

With the trail cameras over the years, we got a lot of sights of the flying squirrels going to check the boxes and even popping inside but not staying in them. No breeding has been noticed in the

trail cam observations so far. Estonian flying squirrels do visit the nest boxes and thus are aware about their availability, but they still seem to prefer breeding in natural dens in the trees.

Lessons learnt

Many questions related to the use of nest boxes remain open. Time will tell whether Estonian flying squirrels will accept the boxes in breeding use later. Perhaps there are more natural cavities or twig dens available in typical flying squirrel forests in Estonia, so that nest boxes are not essential in offering cavity-like nesting places, or it simply takes more time and generations for flying squirrels to adapt to them.

Finland has a long tradition of putting up wooden nest boxes for forest birds around the country, so flying squirrels most probably have seen and encountered them for decades before the building of boxes designed specifically for the flying squirrels began. In addition, as the human settlement in the northeastern part of Estonia is scarce, there are probably also less birdwatchers and other persons wandering in forests and making observations on animal behavior in general.

To conclude, nest boxes cannot be recommended as a solution to maintain flying squirrels: a better way is to safeguard existing suitable habitats and forested connections between them.

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