Flying Squirrel LIFE

Recommendations to develop better future for the flying squirrel in Europe

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Flying Squirrel LIFE: Co-operation for improving the conservation of the flying squirrel in Europe

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The flying squirrel (*Pteromys volans L.*) is an arboreal species endangered in the European Union. This document includes a collection of recommendations which would likely help to improve future living conditions of the flying squirrel in Estonia and Finland. The content is discussed by partners in the Flying Squirrel LIFE project (2018–2025). The document belongs to project action F1.

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Summary

The flying squirrel (*Pteromys volans L.*) is an endangered arboreal species in Europe, and its highest threat is habitat loss linked to various uses of forests. As the flying squirrel typically prefers mature and old mixed forests, which have a high monetary value, conflicts of interest are inevitable and unavoidable. In the EU, the flying squirrel lives in Finland and Estonia, where the species is strictly protected by the legislation. However, the implementation of the legislation to practice seems to have serious challenges as the situation of the species remains endangered. These recommendations suggest activities and solutions, with which the future of the flying squirrel could be better safeguarded. Recommendations have been developed via discussions between partners in the Flying Squirrel LIFE project 2018-2024 and made separately to Estonian and Finnish conditions. In both countries, the importance of safeguarding suitable habitat and moving connections to maintain functional habitat networks in space and time is highlighted. Recommendations focus especially on the clear guidance, development of monitoring and applying the most effective conservation practices, data availability and environmental education, but also to fluent and fair ways for landowners to participate in the conservation of the flying squirrel.

Contents

Background

The flying squirrel (*Pteromys volans L.*, hereafter FS) is an arboreal rodent living in the taiga belt across Eurasia but threatened in the Western edge of its distribution range. Within the European Union, it is now present only in Estonia and Finland with an unfavorable conservation status in both countries: in Estonia, the FS is categorized as critically endangered (CR), and in Finland, vulnerable (VU). In the European scale, FS is near threatened (NT) and seems to be already extinct from Latvia and Lithuania (Amori 2024).

During past decades in Baltia, range of the FS has rapidly shrunk so that now it covers only about 150 forest patches in the North-East corner of Estonia (Estonian Ministry of Environment 2023). In Finland, FS' patchy range still covers almost two thirds of the country. However, the population has been estimated to decline already for decades, even with a fast speed of more than -30 % in ten years (Red Data Book Finland 2019).

The main reason behind the weakening situation of the FS in both countries, and its largest existing threat, is **habitat loss and fragmentation** because of various forest use (Amori 2024). Consequently, habitat patches become smaller and distance between them increases. Smaller habitats offer less resources, and risks such as predation, epidemic diseases, or inability to find essential resources such as food, nests, shelter and a mate, increase in isolated populations. Thus, survival becomes unsure, and accumulating negative effects may lead to extinction. In addition, recent findings suggest that due to low genetic diversity, FS may have a lowered ability to adapt to changes on a genetic level, making it susceptible to adverse effects of habitat change (Ito dos Santos et al. 2024).

As the FS typically prefers mature and old mixed forests, which have a high monetary value, conflicts of interest are inevitable.

Both in Finland and Estonia, FS is listed as a priority species in Annexes II and IV in the European Union's Habitats Directive (Council Directive 92/43/EEC 1992). The Habitats Directive is included in the national nature conservation legislation of EU member countries: Estonia participated the EU in 2004 and Finland 1995.

The aim of the Habitats Directive's Annex II is to ensure enough habitat available for the species, for example via the conservation areas of the Natura 2000 network. FS is present on 12 Natura 2000 areas in Estonia and on 456 areas in Finland. Within these areas the species often inhabits Western Taiga (9010*) habitat types prioritized in the EU.

Annex IV(a) states a strict protection of the breeding sites and resting places, which must not be destructed or deteriorated. The law is applied everywhere, independent of the landownership. Strict protection should ensure the availability of the resources the animals need for resting and breeding also in the future (Commission notice 2021).

However, during the implementation period of the Habitats Directive, FS range in Estonia has been shrinking and population trend in Finland has continued its decline. These signal that maintenance of breeding sites and resting places or ensuring their ecological functionality has not been effective enough.

Flying Squirrel LIFE and recommendations for the future

Maintaining an endangered forest species while filling other needs for forests is a challenging task. The Flying Squirrel LIFE project (LIFE17 NAT/FI/000469; LIFE Public Database 2023) was planned together with key stakeholders to develop dialogue to ease conflicts of interest and to find solutions for practical challenges. The project was titled to co-operate to improve the conservation of FS in Europe. From 2018 to 2025, this was achieved with the 18 participating project beneficiaries in Finland and Estonia (Metsähallitus 2025). All actions of the project were planned to decrease the largest threat for the FS - habitat loss and fragmentation – directly or indirectly. Without LIFE funding these approaches could not have been possible to carry out as a part of common daily work in the participating organizations.

However, even a large project is just a set of tasks during a limited time frame. The Flying Squirrel LIFE project was designed to carry out practical conservation activities and testing conservation methodologies, for example, were not part of the program. The key challenges in species conservation have been discussed in the Flying Squirrel LIFE project together with project partners, and the outcome of those discussions are described in these recommendations. The recommendations are presented separately from Estonian and Finnish perspectives, as situations between countries vary to some extent, and because associated decisions and FS conservation are implemented on a country-by-country basis.

Recommendations presented below are perspectives that beneficiaries working in the Flying Squirrel LIFE project have highlighted, based on expert knowledge with some references to existing research findings and literature. We bring up a range of perspectives, which are observed important in FS conservation practice. The perspectives are educated thoughts which still need further processing. The order of recommendations does not directly reflect their importance, and they do not represent official opinions of the beneficiary organizations.

The main aim of the recommendations is to stop FS habitat loss and fragmentation, either directly or indirectly. We see that using recommendations and applying better practices could help to turn the threatened situation of FS towards a more favorable conservation status in Europe. Responsible conservation authorities and related ministries have the highest power to lead the way. Besides, we would also like to encourage people to search for ways in their own life on how to improve the conservation of FS.

Seen from a wider perspective, many boreal forest biodiversity goals could directly and simultaneously be promoted with FS conservation. FS can be an umbrella species as its habitats often also include habitats important for many other species (Hurme et al. 2008) and as a flagship species it may encourage the conservation of taiga biome in general (Selonen & Mäkeläinen 2017).

More information of the Flying Squirrel LIFE project can be found on the project website: metsa.fi/flying-squirrel-life/

Project publications mentioned are located in a project's subpage: metsa.fi/en/project/flying-squirrel-life/flying-squirrel-guides/

Project code (such as A1 or F1) means project action in question.

These two project publications give a good overview of the topic:

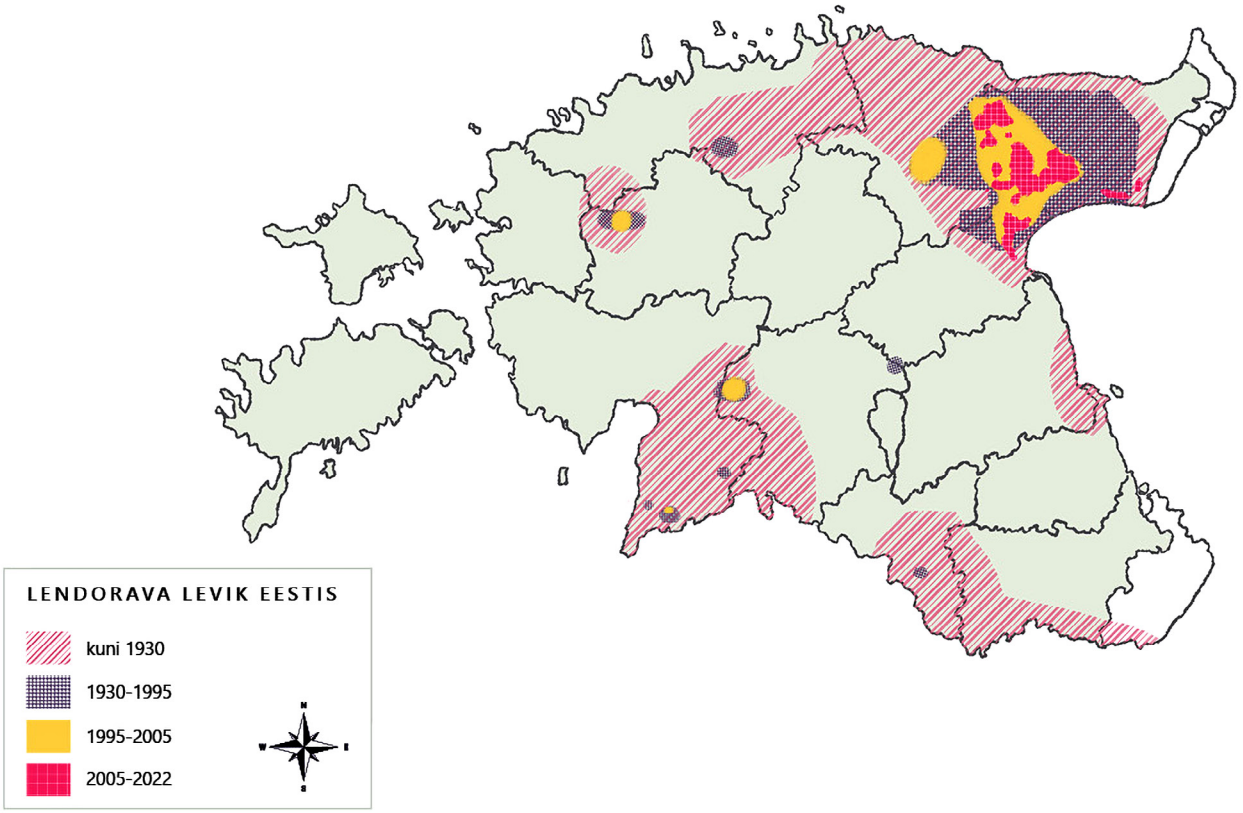
- A1 Description of the current conservation legislation and management procedures of the Siberian flying squirrel (*Pteromys volans*) in Finland and Estonia (2022)
- F1 After-LIFE -suojelusuunnitelma (2025), After-LIFE Conservation Plan for the Flying Squirrel LIFE (including a project summary)

Estonia

Habitat loss and fragmentation are the largest challenges for FS survival in Estonia. The widespread use of modern, intensive forestry practices centered on clear-cutting has resulted in the rapid depletion of forests suitable for FS. Now, approximately 10–20 km² of mature aspen and mixed aspen forests are cut annually in the Alutaguse forest massif, which could potentially be a future habitat for FS. Over the past decade, one-third of mature aspen forests in North-East Estonia (Ida- and Lääne-Viru County) have vanished.

FS is extremely rare in Estonia and its strict conservation is managed by conservation authorities. In practice, decisions of the conservation of important forests for FS are made by the Estonian Environmental Board (Keskkonnaamet) as a conservation authority. FS is listed in Category I protected species.

According to the current legislation, any newly discovered nesting tree automatically receives a 25-meter radius protection zone around it. Since such automatic protection does not yet guarantee the long-term preservation of the site, the next step involves establishing a Species Protection Site (SPS) around representative areas. A SPS typically consists of a core area (conservation zone) and a surrounding limited management zone. The procedures for establishing a SPS have been unreasonably long, and the system needs improvements. Currently, 44 SPS's are designated. The locations of FS are sensitive: detailed information is open only to conservation authorities and other related parties.



> **Picture 1.** Flying squirrel has existed in Estonia for a long time, but its fragmented distribution has shrunken considerably during past decades. At present, the species is found only in the North-East corner of the country, shown with red patches. Map: Keskkonnaamet 2003.

Strict and uncompromising nature conservation policy for protecting the flying squirrel has led to significant conflicts with landowners. The conflict has intensified due to the absence or inadequacy of compensation for income lost. The lack of flexibility in legislation and poor communication between conservation authorities and landowners have not eased the situation either.

In the **National Action Plan for the flying squirrel in Estonia**, the background and solutions to ease the situation are described in detail (Estonian Ministry of Environment 2023). However, there are some points in the national action plan we see important to highlight here.

We present eight (8) recommendations in Estonia:

- Proposal to the Conservation Law
- Promoting the development of future habitats
- Establishing conservation easements (volunteer conservation)
- Promoting innovative funding opportunities
- Promoting landscape scale planning
- Development of a genetic monitoring method for assessing the status of the FS population
- Public involvement and awareness-raising
- International cooperation

Proposal to the Conservation Law

We propose establishing a minimum requirement of a species protection site as having a 150-meter radius around FS nesting trees. A more efficient compensation system for private forest owners must be introduced at the same time.

This protection site would cover about seven (7) hectares and could be automatically created and adjustable thereafter. Additional criteria should be developed to refine this approach, such as limiting automatic protection to forest areas above a certain age or height threshold, ensuring that open areas (e.g. fields or young forest stands) are not included. The rationale for this radius is based on research indicating it almost corresponds to an average home range size of a female FS, which is approximately eight (8) hectares. The implementation of this statutory automatic protection zone would reduce bureaucracy and simplify the protection of forests crucial to FS and many other species. This approach would also prevent the planned logging around a small patch of an automatic protection (25-meter radius around a nesting tree), which would typically be carried out as standard practice. When moving connections are broken there are no future for small patches.

We believe that such a legal amendment would have a significant positive impact on the flying squirrel population. This decision requires political commitment and simultaneously, a more attractive compensation system for private forest owners must be introduced. The compensation system could consist of different possibilities for the landowners: annual compensation, selling the land to the state and land exchange with the state. The fair compensation system is already developed as part of the LIFE IP ForEst & FarmLand project, aiming to create a fair compensation framework that considers both the strictness of restrictions and the quality of the forest.

Promoting the development of future habitats

We advocate for continuing to develop FS-friendly forest management plans with a long-term perspective to ensure the persistence and resilience of FS populations and their habitats. Additionally, we suggest providing technical assistance, training, and financial support to forest owners interested in implementing these management practices in their forests. Metsakorralduse Büroo OÜ (MKB) is ready to build on its experience by creating new FS-friendly forest management plans for private forest owners. Having already developed 30 management plans covering over 858 hectares during the Flying Squirrel LIFE project, MKB has the expertise and practical knowledge to support landowners in implementing sustainable forestry practices that help to protect FS habitats. We are committed to expanding this work by offering detailed planning, technical support, and practical solutions to ensure that private forests continue to provide safe and suitable environments for FS while meeting the owners' forestry goals. Formative cuttings should be allowed if they do not damage the habitat and/or have a neutral impact, and in the long term may have a positive effect on forest habitat development.

Establishing conservation easements (volunteer conservation)

In addition to "classical conservation", we propose introducing and developing mechanisms such as conservation easements, which offer voluntary agreements between landowners, government agencies, or private initiatives. Under these agreements, landowners agree to restrict certain activities on their properties in exchange for financial incentives or other benefits. This approach allows for the protection of mixed aspen forests while respecting the rights and interests of landowners. We also recommend developing and promoting the already existing woodland key habitats system regulated by the Forest Act to make it more attractive to forest owners.

Promoting innovative funding opportunities

We propose exploring innovative funding opportunities such as biodiversity credits as a funding mechanism for FS conservation, in line with the principles set by the Biodiversity Credit Alliance (BCA). Biodiversity credits represent measurable, verifiable conservation outcomes that can be financed by private sector entities, aligning investment with nature-positive goals.

By developing a biodiversity credit system tailored to FS habitat protection needs, new financial incentives could be created for landowners to preserve flying squirrel habitats outside protected areas. This could involve:

- Compensating private landowners for maintaining mature aspen and mixed forests, ensuring habitat continuity;
- Encouraging businesses to invest in biodiversity-positive activities as part of their corporate sustainability strategies;
- Aligning biodiversity credit mechanisms with Estonia’s implementation of the EU Nature Restoration Law, ensuring long-term funding for habitat continuity.

Additionally, by combining biodiversity credits with carbon offsetting solutions, we can enhance the value of conservation investments, addressing both biodiversity and climate change mitigation goals. These initiatives should be primarily driven by the private sector, but the state can play a key role in developing regulatory frameworks and incentives to promote the adoption of biodiversity credit markets in Estonia.

Landscape scale planning

The aim of landscape planning is to ensure the existence of moving corridors between FS habitats. So far, such planning has been carried out on the state land (by Riigimetsa majandamise keskus, RMK). We propose to include private lands to this planning schema to achieve shorter and more natural connections between habitats. The involvement of private landowners should encompass both volunteer participation as well as compensating measures. The examples of the latter could be the exchange of land between the state and private landowners, land rental or purchase by the state, etc. Pilot projects between the state and private landowners could be one possibility.

Another aspect of landscape planning that is worth further discussion, is the increase of harvesting age in the forest types that could be potential habitats for FS. This could mitigate the habitat deficit in the FS occurrence area by creating spatio-temporal dynamics of suitable habitat patches in the managed forests. In the state forest in particular, such planning should become a part of normal forestry practice.

Development of a genetic monitoring method for assessing the status of the FS population

To ensure the long-term monitoring of the FS population and effective planning of the conservation measures, we recommend developing a genetic monitoring method based on genetic markers. This approach would enable the analysis of genetic diversity, inbreeding, dispersal, gene flow, habitat use, and population density. This is a crucial step in developing evidence-based conservation for the FS, enabling a more accurate assessment of population viability and implementing more effective conservation strategies.

Key activities for developing the method:

- Identifying the most informative SNPs (single nucleotide polymorphisms) in the FS genome;
- developing a reliable sample collection and preservation system to ensure high-quality data;
- testing and calibrating the next-generation methodology in a pilot project, creating a foundation for broader population analysis;
- collecting genetic samples from all known occupied habitats in subsequent monitoring efforts, conducting a comprehensive analysis of the Estonian FS population;
- including samples from Finland and beyond to gain a better understanding of population connectivity and gene flow.

Public involvement and awareness-raising

To strengthen public awareness and stakeholder engagement in FS conservation, we recommend a comprehensive outreach strategy that includes educational events, continuous advisory services and media outreach.

Each year, some training days should be organized for landowners, forestry consultants, officials and others to enhance their understanding of FS ecology and habitat conservation. In addition to these events, ongoing advisory support should be provided to private forest owners, forestry consultants and specialists to ensure sustainable forest management in FS habitats. It is essential to promote conservation-friendly solutions on private land, particularly in supporting ecological corridors outside protected areas, through direct engagement with landowners.

Public outreach efforts should be expanded in FS range areas through awareness events, such as nature evenings, public hikes and volunteer camps, alongside increased media coverage in radio, television (e.g., "Osoon"), and print media (e.g., Eesti Loodus, Eesti Jahimees). Collaboration with Tallinn Zoo and leading environmental organizations, including the Estonian Fund for Nature, the Estonian Naturalists' Society, and the Estonian Theriological Society, will further enhance public engagement.

Additionally, educational materials on FS research and conservation should be continuously developed and updated to reinforce the image of Virumaa (Alutaguse) as "a stronghold for FS conservation".

International cooperation

We recommend maintaining close cooperation between Estonia and Finland also after the end of the Flying Squirrel LIFE project, ensuring that conservation strategies remain aligned and that international collaboration would support the species' protection in the long term. Future cooperation could include joint monitoring efforts, new pilot projects and sharing of knowledge on the best conservation practices.

Scientific cooperation should be further strengthened by fostering partnerships with research institutions and universities to advance genetic studies and other scientific projects. Long-term monitoring and research are crucial for understanding population dynamics, genetic diversity, habitat connectivity, and the effectiveness of conservation measures. Beyond regional cooperation, it is essential to establish contacts with researchers and conservation organizations in other range states, to exchange research findings and gain a more comprehensive understanding of FS status across its entire distribution range.

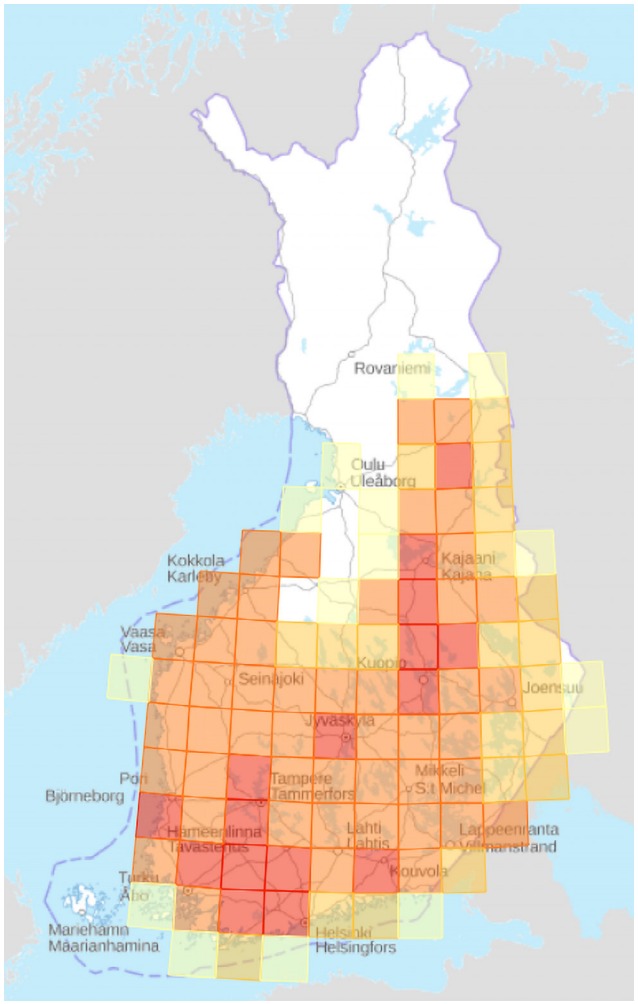
> **Picture 2.** Flying squirrel in Estonia. Photo: Tõnu Laasi.

Finland

Habitat loss and fragmentation are the largest challenges for FS survival in Finland. Majority of FS in Finland live outside established nature conservation areas. This highlights the importance of high-quality land-use and forest planning as well as careful management and activities. FS range in Finland covers almost two thirds of the country, but its occurrence pattern is patchy. This means that in some regions FS is rare or non-existent, while for example in many urban regions, the species may seem locally almost common.

At the national level since the 2000's, estimations of FS population trend are based on systematic monitoring of a sample of forest areas. Results have showed a continuous and fast decline at a speed of more than -30% per 10 years (Red Data Book Finland 2019). There are also signs that the population decline may be faster than expected even though suitable habitat would seem to be available (Koskimäki et al. 2014). However, understanding of the actual population size in Finland is missing – partly as it has been difficult to detect the number of individuals for a nocturnal, silent and short-lived arboreal species. Even the scale seems problematic as rough population estimates made in the 2000s varied from about 300 000 (Hanski 2006) to about 100 000 (Sulkava et al. 2008) based on statistical estimations of a large-scale sample study. As the FS range covers a large part of Finland, no detailed national inventories are done. Indeed, many of the observations relate to inventories done in various land use planning processes.

The landowner or their representative has the responsibility of not to deteriorate or destruct breeding sites or resting places of FS (Nature Conservation Act 9/2023) in Finland since 2016. Regional ELY Centre (Centre for Economic Devel-opment, Transport, and the Environment) that is responsible of monitoring the implementation of the Nature Conservation Law in Finland, can give advice.



> **Picture 3.** Example of observations of the flying squirrel sent to the national database of laji.fi during 1995-2021 (Suomen lajitietokeskus 2022, Selaa havaintoja | Suomen Lajitietokeskus). The more observations, the redder color in a square. Many FS observations relate to inventories made in various land use planning processes. Population trend estimations are based on systematic monitoring of a sample of forests.

Thus, many people and professionals need to be aware of populated habitats and know what to do so that the right decisions can be made case by case. In Finland, unlike in Estonia, information of known FS locations is open and available through national Laji.fi species data management service (Lajitietokeskus 2025). It is thus possible to see where FS has earlier been located and use that information for land-use planning. However, as no thorough national surveys have been carried out and situations differ over the years, available data is not perfect. Species inventories are needed to understand the current situation in the forests case by case.

There is also guidance on how to consider FS in managed forests (Tapio Oy 2016), supported by the ministry of agriculture and forestry (MoAF) and the ministry of the environment (MoE), and in urban areas by the MoE (Ympäristöministeriö 2017). During the Flying Squirrel LIFE project (2018-2025), several new education materials with many true examples of forest plans were prepared to illustrate existing legislation, in collaboration with conservation authorities. However, these are "just" project publications without official stamps.

Indeed, time has passed since the ministries (MoE and MoAF) gave the above-mentioned guidance materials. Clear guidelines with effective and fluent practices are needed for authorities, professionals and landowners, so that the goal of safeguarding FS can be reached together. The legislation is the same for all landowners, private or public, but based on the continuing fast decline in the population, the FS safeguarding system does not work efficiently. Recent findings of the low genetic diversity of FS also highlight the importance of finding effective conservation practices especially in Finland, where the largest FS population in the EU exists (Ito dos Santos et al. 2024).

Recommendations presented below are perspectives that beneficiaries working on the Flying Squirrel LIFE project have highlighted. They are based on experiences of experts with some references to existing research findings and literature. A range of educated thoughts are brought up, which still need further processing. The order of recommendations does not directly reflect their importance, and they do not represent official opinions of the beneficiary organizations.

We present seven (7) recommendations in Finland:

- Updating official guidance
- Improving practical guidance to maintain breeding sites and resting places
- Ensuring better knowledge and continuous learning for practitioners at all levels
- Increasing landscape level and cross-border approach in land use planning
- Developing conservation practices, FS monitoring, and research approaches
- Improving practical tools and processes for forest owners
- Increasing general environmental education to all levels

Updating official guidance

We recommend that responsible conservation authorities and ministries together update guidelines on how to safeguard FS (e.g., Tapio Oy 2016, Ympäristöministeriö 2017). It would be important to formulate clear guidelines and supporting processes which do lead to safeguarding FS. One could also consider whether preparation of a national action plan or similar broad-scale approach is needed for FS (compared to the national action plan in Estonia). The flying squirrel has been declining already for a long time, indicating that the aim of the legislation is not reached in practice.

Improving practical guidance to maintain breeding sites and resting places

In the nature conservation legislation, "a breeding site and resting place" is a central concept. Strict protection of these sites and places means that they must not be deteriorated or destroyed. This sounds clear, but each forest and its neighborhood are unique to some extent, as is the configuration of important forest sites for FS within a larger area. As the clear definition of this concept is missing, there exists a large variation in how breeding sites and resting places are defined in practice. In addition, there are no clear guidelines for how much and what kind of forest should be maintained around these sites, or how far the FS moving possibilities should be ensured.

FS is a forest species. Essential resources for FS are typically found in mature spruce-dominated forests with deciduous trees in a mixture. It has also been shown that especially females need relatively large, sheltered forests to raise their cubs (e.g., Hanski 2016). Detailed monitoring has revealed that the survival of female FS is higher in forest patches larger than four hectares than in smaller patches (Wistbacka 2022).

It has also been officially noted by the EU Commission that strict protection of breeding sites and resting places should ensure sufficient resources for the animal to continue breeding and resting required in the future (Commission Guidance Document 2021). Furthermore, an older breeding site and resting place, without recent observations of FS presence, should remain protected if its condition is still so good that FS could start using that again (Muu päätös 2451/2023).

"Breeding sites and resting places" are central areas, but monitoring of them has shown that sites for FS have earlier been delineated too small (Jokinen 2019, Wistbacka 2022), and that the problem is not yet fully solved (e.g., Salonen 2022). Now, strong statements underline the need to define a breeding site and resting place of FS as a forest area that covers 4-6 hectares (e.g., Sulkava 2024, Yli-Karjanmaa 2024).

Clearer guidance would likely diminish the variety of interpretations and support the work of conservation authorities. This could lead to more effective conservation of the FS. From a practical perspective, guidance of the quality and quantity of forest areas for different management options - to be left uncut, or only very carefully managed - would be very useful for people making decisions but especially for the FS' survival.

We recommend improvements to guidance:

- **Sufficient resources for conservation authorities to give advice and control following the legislation.**

  Regional ELY Centers (Centers for Economic Development, Transport, and the Environment; "Elinvoimakeskus" to be 2026-) are public authorities responsible of the Nature Conservation Law. The present law also states that ELY Centers can advise on FS issues.

  - **What is legal and what is not** should be written clearly to the guidelines, so considering the FS would be easier in practice for authorities and practitioners across the species range.
  - The option of getting advice from ELY Centers is not well known among landowners. All forestry notifications related to FS are forwarded to ELY Centers, but the risk remains that advising come too late. Now, ELY center can monitor the forest use only afterwards, and only if there are resources for that. The unity in getting advice and getting help on time would ensure experience of equality and fairness among landowners. Good experiences would likely increase positive attitudes towards conservation and lead to better safeguarding of FS.

- **Clear and practical guide material**
  - **Clear definitions for breeding sites and resting places and how they are considered.** Even though it can be challenging to define a "one-fits-all" solution, addressing an official commitment on their size, i.e., compared to the 4-6 hectares highlighted by research, may be needed. Simple guidelines with examples with scales and illustrations help to identify the important parts of forests. Following the guidance in different forests is then possible and leads to better decision making both in urban and managed forests.
  - **Considering the ecological functionality at a landscape scale.** How the surroundings of breeding sites and resting places should be described and what could be done there so that animals can move between forest areas. This may need larger-scale planning irrespective of the ownership of land.
  - **United terminology and their ecological interpretation: guidance for inventories.** The logical flow on how observations made in FS inventories are turned to legal definitions of breeding sites and resting places. Typical observations made in species inventories relate to, for example, forest structure, (number of) droppings under a tree, nesting trees, feeding areas, and potential nesting trees or potential habitats at forest sites. These observations are further translated into ecological meanings of areas for FS, for example to core area, territory, and home range. This "translation" is an important part in understanding the situation, but naturally, the interpretations often vary. In practice, skills and experience in FS inventories are needed. An open register would help to find an expert for the task.

- **The timing of FS inventories based on droppings should be limited only to spring.** The best time to find distinctive FS droppings, indicating its presence in the forest, is known to be spring as in other seasons droppings are more difficult to find. A flying squirrel forest can be cut if it is not noticed just because of unsuitable inventory time. The right inventory time could be one criterion in a high-quality inventory.

- **Nature detection dogs are a novel approach to assist FS inventories.** The use of nature detection dogs could be encouraged especially at challenging planning sites and to inventories outside spring. Existing experiences from nature detection dogs are excellent: trained dogs seem to locate even such FS traces which humans cannot easily find, such as single old droppings or melted droppings (e.g., Varsinais-Suomen ELY-keskus 2022). A dog can detect ecologically important areas like feeding and moving areas as well as potential habitats which humans have not observed occupied lately or at all. A well-trained dog can be seen as a neutral tool as it just recognizes a scent or not and doesn't have an opinion (Hurme & Karpela 2023). A detailed education program to teach nature detection dogs for FS already exists, and a certificate system is in progress.

In the Flying Squirrel LIFE project, many concrete activities were directed to improve habitat networks in urban areas in Finland and to maintain habitat networks in managed forests in Finland and Estonia. In Finland, examples were prepared during 2018-2022 to illustrate existing legislation and were advised by regional ELY Centers. In managed forests, site plans aimed to maintain sufficient habitat for FS i.e., several hectares of forest in total per site.

Project sites:

- A5 Summaries of conservation plans in urban project sites (2025)
- A6 Maintaining habitat network in state-owned managed forests, project site documentation (2025)
- A6 Forest use plans for private forests in Finland: maintaining habitat networks on private land (2025)
- A6 Forest management plans related to Natura 2000 area in Rekijokilaakso (2025)
- A8 Supporting the aspen continuity, project site documentation (2025)

Landscape scale:

- A3 Predictive habitat map layer (2021) downloadable to GIS in Lajitietokeskus: laji.fi/about/5922
- A3 Predictive habitat map layer (2021) downloadable to GIS in Paikkatietoikkuna: kartta.paikkatietoikkuna.fi
- D3 Summary of the Flying Squirrel LIFE project's effects on forest ecosystem function (2025)

Guides and reports:

- A2 Liito-orava. Tietoa lajista ja kartoituksesta (2020), guide for inventory
- A2 Dog-assisted flying squirrel inventories, summary (2022)
- A4 Liito-oravan huomioiminen kaupunkisuunnittelussa – hyvien käytäntöjen opas (2021), guide for urban planning
- A7 Liito-orava talousmetsässä – opas liito-oravan suojelun ja metsätalouden yhteensovittamiseen (2023), guide for managed forests
- E3 Liito-oravan jäljillä (2021), guide for environmental education

Ensuring better knowledge and continuous learning for practitioners at all levels

Better knowledge likely leads to better practice. When FS can be considered as early as possible in the planning process, and good advice is received when needed, the outcome will be better. In addition to clear guidelines, advice and education events should be available regularly for professionals at all levels. The need to improve and update knowledge is important especially to professionals who make forestry plans or advice forest owners, or land use planners.

We recommend that continuous learning possibilities for those in need such as authorities, professionals, landowners and other stakeholders are ensured nationally with sufficient resources:

- **Regular education events.** Besides clear and up-to-date guide materials and advice, e.g., webinars and practical training events are important. Ecological features, such as characteristics of FS habitats across its range in Finland, can be properly understood only in the nature. Unfortunately, the continuum of FS education events is now an open question.
- **The use of existing species data through Laji.fi service (Lajitietokeskus 2025).** Knowledge should be increased and include the use of FS observation data to general guidance. As there are no systematic and detailed censuses carried out throughout the species' range, all existing observations should be used as signs: an observation may be inaccurate or an area seeming empty may just be without any inventories. Thus, FS inventory is always good to do as a part of a careful land use planning process.
    - All FS observations gathered in various nature inventories could be saved to Laji.fi, a task that could be included already in inventory contracts. If FS observations are not registered in the open data systems, they do not exist and cannot be used in practice.

In the Flying Squirrel LIFE project, over 60 educational events were directed at many professional levels 2019-2024. They gained over 3000 participants, highlighting the existing need to understand FS issues better. In addition, knowledge and the use of Laji.fi service was enhanced. Lajitietokeskus now has a themed website for FS, where guidance materials and data can be found (Lajitietokeskus 2025b).

- Flying squirrel page "Liito-oravan suojelu ja elinympäristöjen turvaaminen": laji.fi/about/5660
- Species database: Selaa havaintoja | Suomen Lajitietokeskus

Increasing landscape level and cross-border approach in land use planning

Focusing only on a limited area at a time may prevent noticing other useful perspectives. Forest planning is often done at a single estate at a time, or land-use planning is carried out in a small part of a municipality: neighboring estates or municipalities are not typically considered. Larger spatial scales here, for example, could mean enlarging the planning perspective from a couple of hectares to tens of hectares, and even to tens of square kilometers, depending on the context in question.

For FS, considering larger spatial scales for suitable habitats and moving connections between them could ensure ecologically functional networks. Furthermore, this would likely improve the maintenance of living conditions for populations in the long term. Continuity of habitats and moving connections in space and time could be estimated if larger areas could be planned across long time periods. Yet, there do exist tools and methods to do this, so in principle, large-scale planning could be enhanced even at the national scale over decades.

We recommend the consideration of spatial and temporal scales is developed:

- **Development of the landscape scale approach** would need wide co-operation between key stakeholders and the application of suitable GIS methods. It would be good to estimate possi-bilities of **volunteer protection programs, land-use planning** (also up to, e.g., master plans or regional land use plans) and **incentives**. Including the forest owners in the process would likely improve the acceptance of the planning. Besides FS, landscape scale planning could include also **other species and habitats**, different **conser-vation areas** and **green networks**. Applying a **time scale** would improve estimations of future forests and how availability of suitable habitats can be ensured in the long term.
- Cities and municipalities typically manage large areas with complex goals, which have direct connections to FS. Their land use management planning could **first aim to illustrate habitat networks for the flying squirrel at large scales and then adjust other patterns within it**. Focusing only on small planning sites at a time should be avoided, as the relation of decisions to the underlying habitat network cannot be estimated. An understanding of the large habitat network with existing habitats and forested connections between them helps in planning other land use, as possible restrictions would be open to all potential construction projects on time. A better overall picture of the underlying situation can decrease risks of delays in construction processes, that often happen due to sudden observations of FS but also ensure equality of construction projects.
- **Co-operation between neighboring forest owners** could be improved by planning of habitat networks together across larger areas. Considering FS with other goals of forest owners could help to find other synergies as well. For example, sometimes cutting costs may be reduced if forestry measures could be adjusted together across larger spatial scales, also along a longer time span.

In the Flying Squirrel LIFE project, map layers which illustrate potential FS habitats were built to help to notice the potential habitats and moving connections between them. The additional value of habitat models is already received, as in Estonia, FS inventories were targeted to predicted forests, which resulted in tens of new FS findings. Naturally, various forest data estimates of forest growth and aerial photographs are already in everyday use by planners. Networks of suitable FS habitats and forests enabling movement between them are already illustrated in GIS systems of many organizations. Project beneficiaries Espoo, Jyväskylä and Kuopio use habitat network approach for urban land use planning, but it is also used for planning forest management in state-owned forests both in Finland (Metsähallitus Forestry ltd, Finland) and Estonia (Riigimetsa Majandamise Keskus).

- A3 Map layer of a predictive habitat model available in Finland (laji.fi laji.fi/about/5922 and Paikkatietoikkuna (kartta.paikkatietoikkuna.fi)
- A5 Jyväskylä region, habitat network model / Summaries of conservation plans in urban project sites (2025), a landscape optimization analysis
- D3 Summary of the Flying Squirrel LIFE project's effects on forest ecosystem function (2025)
- D3 Metsänkäsittelyn vaikutus liito-oravalle suotuisiin elinympäristöihin (2024), future scenarios

> **Picture 4.** The existence of flying squirrels within their natural range is dependent on individual survival and the success of reproduction year after year. Flying squirrels use many nests around the year but are site-tenacious at their large home ranges. During their first autumn, young flying squirrels need to find their own home ranges. All aspects of a successful life cycle underline the need to maintain a functional habitat network. It includes suitable forest habitats and forested connections between them for moving seen at large spatial and temporal scales. Photo: Benjam Pöntinen.

Developing conservation practices, FS monitoring, and research approaches

Now, efforts to systematically study the effectiveness of conservation practices of FS are missing, although the evaluation of forest use effects on the FS occurrence would be essential. Nationally, FS inventories are carried out almost annually using a sample of forests, which has been the basis for population trend estimations since the 2000's. Resources directed at monitoring vary, though.

Scientific research on FS has been active in Finland since late 1990's with a wide range of ecological, social, and socio-economic approaches. Lately, the activity in research has decreased. It has also been noticed that ecological research findings made in managed forests do not necessarily directly apply to urban conditions. A better knowledge of the existing situation as well as understanding related mechanisms and patterns would be very important. Furthermore, exchange of knowledge between different professionals would ensure wider understanding and help to develop effective conservation practices in the future.

We recommend developing research and the use of knowledge in planning conservation practices:

- **Systematic studies on the effectiveness of conservation practices with a regular census of FS in the long-term.** Both are important parts of understanding the national situation of FS and developing effective guidance based on knowledge. Accumulating data and updating guidance according to it, as well as openness of results and methods used, likely also improve the acceptance of the conservation.
- **Encouragement for research.** Applying funding to research programs is often challenging. FS related biological, ecological, juridical, socio-economic, and social science approaches could still be fruitful. Research questions could, for example, relate to better understanding of ecological functionality, ecological boundary conditions, and urban perspectives. Perspectives related to social science and socio-economics are also needed, as the human part is central in species conservation.
- **Interaction between different stakeholders and professionals.** A wide exchange of knowledge between professionals representing various fields would be very important in the planning of the FS conservation. Continuous connection between Finland and Estonia but also at international levels would increase possibilities to keep up with up-to-date research and methodologies, as well as enable broader understanding of different perspectives.

In the Flying Squirrel LIFE, project sites have been monitored even for five consecutive years for FS occurrence. Long time series are important as FS typically has a short life: even a good forest may sometimes seem empty just because a resident has passed away and a new individual has not yet reached it. FS monitoring data collected during the project is waiting for further analysis with research organizations after the project.

- D1 Monitoring report (2025)

In the Flying Squirrel LIFE project, very good experiences were gained from different concrete tasks, which were prepared together with project partners. Commitment to a long project strengthened the tolerance of complex situations, and possibilities to find solutions to difficult planning situations. It is a rather open question, how to continue dialogue and co-operation between stakeholders after the project.

Improving practical tools and processes for forest users

As the majority of FS in Finland exist outside conser-vation areas and the responsibility to consider FS rests on the shoulders of land and forest owners, practical processes should be as fluent as possible. This would safeguard the FS better and increase the acceptance for conservation both in urban areas and outside them. In practice, forest management often falls in the middle of public and private sectors.

However, forest owners are not very familiar with asking for advice from the ELY Centre. Forest owners are often connected to forestry associations, which do not always have up-to-date expertise related to FS. It often happens that a landowner gets the first information of FS in their estate during the process of the forestry notification system. In Finland, a forestry notification of a management plan must be sent to the Finnish Forest Centre that is responsible of the Forest Act. If a national species data system (laji.fi) includes a note of FS at the estate or its close neighborhood, a forest notification is forwarded to the ELY Centre for evaluation. If ELY Centre does not send comments in 10 days, planned forestry measures can be implemented. However, the lack of response from the ELY Centre on time itself does not confirm that the plan was good enough, as there might have been unfortunate delays. If the response from ELY Centre comes too late and cuttings are already done, conservation of FS is often failed - and the working time of the authorities is wasted.

We recommend the development of tools and processes:

- **Forestry notification systems should be developed to be more fluent for all users, and sufficient resources for authorities ensured.** Now there are delays due to the flow of information and feedback. Besides offering good guidance, forest owners should be encouraged to ask advice as early as possible but also question if the response time given to ELY Center could be elongated. Technically, the inclusion of a detailed explanation of how FS would be considered at the estate should be possible, as it would help to estimate the quality of a plan. In developing fluent and efficient systems, approaches from service design may offer fruitful perspectives to practical challenges also related to FS conservation (Heikkinen 2024).
- **The compensation procedure should be clear and open.** Now, a landowner can apply compensation from the ELY Centre if the expected loss of monetary income of timber due to FS protection is too large compared to the forest property. The procedure, however, often seems complicated and receiving a decision may take time. Clear guidance and forms as well as open calculation methods would increase experiences of equality and fairness.
- **Combinations of different compensation sources should be investigated.** It is not yet known if nature care methods (e.g., increasing deciduous trees), or METSO volunteer protection program could be combined with the compensation related to saved forests for FS. These perspectives may have synergies with climate change and species loss.
- **Novel and alternative funding opportunities to maintain forest biodiversity should be investigated.** Additional funding could encourage forest owners to maintain more important nature features in their forests. Perhaps the price for timber could, for example, be higher for forest owners who use lighter forestry measures, or otherwise take FS into account exceptionally well?

In the Flying Squirrel LIFE project, good experiences were gained from meetings with landowners. Landowners appreciated personal discussions with the authorities and their advice based on legislation for conservation and forests. As a result, tens of FS friendly forest plans were made and over 150 hectares of new conservation areas were agreed in Rekijokilaakso area in South-West Finland..

- A6 Forest management plans related to Natura 2000 area in Rekijokilaakso (2025)
- E2 Description of engaging landowners Finland (2025)

Increasing general environmental education to all levels

FS can be seen as a good example species for interaction between a species and its habitat. Understanding why the maintenance of biodiversity is important is a central task when considering FS but also any nature conservation related to different land-use regulations. Environmental education approaches could be used to explain complex phenomena, and as a result, it could increase the acceptance of nature conservation – irrespective of the age, experience or professions of people.

Perspectives recognized from FS may be more generally applied to conservation of biodiversity. However, attitudes towards FS may be affected by media where some headlines may emphasize the conflictual nature of the phenomenon. In addition, the knowledge of FS biology, its state as a threatened species, and basic forest ecology may be limited or even skewed. Population size estimate may sound large, or trend estimations false. If FS seems to be common in one's own municipality, it may be difficult to understand the decline of the species on the national scale. Environmental education could be a way to increase better understanding and thus have an important role in easing sometimes opposing views related to nature conservation.

We recommend the development and increasing of environmental education:

- **Focusing on forest ecology and the importance of maintaining biodiversity.** Combining FS conservation with larger questions may increase understanding of species protection as a part of nature. FS may serve as a practical example in explaining it and offer possibilities to illustrate and explain large-scale issues and problematics.
- **Communicating the importance of FS protection from the perspectives of other species and people could open views to search for potential win-win situations.** Offering FS related topics to media can be formulated from a positive perspective and direct to finding solutions. Orientation towards hope and solutions could also help in decreasing environmental anxiety related to climate change and other worries. Focusing on opposing views or conflicts is not needed.
- **FS related environmental education events and materials bring the knowledge closer to the general audience.** The use and marketing of already existing materials can be done, but also new methods, such as mobile applications and the use of live cameras for citizen science, can be developed further. It is also good to encourage new educators along, for example, by arranging education for teachers at different organizations.

In the Flying Squirrel LIFE project, various open FS-themed events were very popular, and participants already had a positive attitude towards it and biodiversity. The challenge is how environmental education could reach those who are not so interested or may even have a negative perspective on the topic. However, our finding is that face-to-face discussions with time are an effective way to increase the better acceptance of the FS conservation.

- E3 Liito-oravan jäljillä (2021), guide for environmental education
- A6 Forest management plans related to Natura 2000 area in Rekijokilaakso (2025)
- D2 Summary of the socio-economic effects of the Flying Squirrel LIFE project (2025)

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All publications of the Flying Squirrel LIFE project can be found on the project website:: metsa.fi/en/project/flying-squirrel-life/flying-squirrel-guides/

Project publications in the order they are referred to in the text:

- A1 Description of the current conservation legislation and management procedures of the Siberian flying squirrel (Pteromys volans) in Finland and Estonia (2022)
- F1 After-LIFE Conservation Plan (2025) for the Flying Squirrel LIFE including a project summary
- A5 Summaries of conservation plans in urban project sites (2025)
- A6 Maintaining habitat network in state-owned managed forests, project site documentation (2025)
- A6 Forest use plans for private forests in Finland: maintaining habitat networks on private land (2025)
- A6 Forest management plans related to Natura 2000 area in Rekijokilaakso (2025)
- A8 Supporting the aspen continuity, project site documentation (2025)
- A3 Predictive habitat map layer (2021) downloadable to GIS in Lajitietokeskus: laji.fi/about/5922
- A3 Predictive habitat map layer (2021) downloadable to GIS in Paikkatietoikkuna: kartta.paikkatietoikkuna.fi
- D3 Summary of the Flying Squirrel LIFE project's effects on forest ecosystem function (2025)
- A2 Liito-orava. Tietoa lajista ja kartoituksesta (2020), guide for inventory
- A2 Dog-assisted flying squirrel inventories, summary (2022)
- A4 Liito-oravan huomioiminen kaupunkisuunnittelussa – hyvien käytäntöjen opas (2021), guide for urban planning
- A7 Liito-orava talousmetsässä – opas liito-oravan suojelun ja metsätalouden yhteensovittamiseen (2023), guide for managed forests
- E3 Liito-oravan jäljillä (2021), guide for environmental education
- Flying squirrel page "Liito-oravan suojelu ja elinympäristöjen turvaaminen": laji.fi/about/5660
- Species database: Selaa havaintoja | Suomen Lajitietokeskus
- A5 Jyväskylä region, habitat network model / Summaries of conservation plans in urban project sites (2025), a landscape optimization analysis
- D3 Summary of the Flying Squirrel LIFE project's effects on forest ecosystem function (2025)
- D3 Metsänkäsittelyn vaikutus liito-oravalle suotuisiin elinympäristöihin (2024), future scenarios
- D1 Monitoring report (2025)
- E2 Description of engaging landowners Finland (2025)
- D2 Summary of the socio-economic effects of the Flying Squirrel LIFE project (2025)

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Jyväskylän kaupunki / City of Jyväskylä (JYVÄSKYLÄ)

Kuopion luonnontieteellinen museo / Kuopio Natural History Museum - City of Kuopio (KULUMUS)

Kuopion kaupunki / City of Kuopio (KUOPIO)

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