Proposed Commercial Forestry Development, Lochranza, Isle of Arran

Ecological Impact Assessment

September 2023

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Github Repository

The data and metadata used for this document, including the raw data, annotated codes, graphic outputs and all other related documents can be found on the following public Github repository:

https://github.com/Hayward-Wong/Arran_EcIA_Data
DOI: 10.5281/zenodo.10279425

Executive Lay Summary

Commercial forestry developments are in consideration at two plots located at Lochranza on the Isle of Arran in the Firth of Clyde, Scotland. The two plots will be referred to as the Northern Plot and the Southern Plot for the rest of the document. This Ecological Impact Assessment aims to summarise the one week survey conducted by our team of 12 members, outlining the baseline condition and evaluating the potential ecological effects on two plots.

The assessment on site mainly focused on plant, vertebrates and invertebrates species richness and abundance as per the landowner’s demand. Desk-based survey revealed that the Southern Plot is part of the Arran Northern Mountains Site of Special Scientific Interest (SSSI) and any changes in woodland management would require consent from the Scottish Natural Heritage. Given the complexity and variety of plant species, and considering the limited expertise in botany within our team, we decided to focus on identifying key species crucial for habitat classification, along with vulnerable or protected species, and invasive species. This approach was facilitated by a desk-based survey prior to the field survey, ensuring that we could at least recognize these species in the field. Due to time and resources constraint, for our additional field surveys we targeted specific taxa of plant, vertebrates and invertebrates including Trees, Birds, Mammals, Terrestrial Invertebrates and Aquatic Invertebrates, sampling using a wide range of techniques including Transect walks, Point Counts, Camera Traps, Audiomoths, Pitfall traps, Sweep-netting and Kick sampling.

Our survey result showed both plots exhibiting comparable diversity and abundance across Bats, Terrestrial Invertebrates, Aquatic Invertebrates and ASPT score of 5 suggesting excellent water quality. However, there are significant differences in their habitat composition and in their mammal, bird and tree populations. The Southern Plot recorded a higher richness and abundance of trees, including a significant presence of Silver Birch woodland, a key feature of its ecological landscape and the Arran Northern Mountain SSSI and the largest Silver Birch Woodland of the SSSI can be found in Lochranza. Bird diversity in the Southern Plot had a more even distribution of species abundance, suggesting a more diverse and desirable bird population.Red deer were abundant and only found in the Southern Plot, and overgrazing from Red Deer is one of the major impact the Silver Birch Woodland in the SSSI is currently facing. In contrast, The Northern Plot has a larger bird population than in the Southern Plot but is dominated by species of least concern and invasive Kestrel that prefer open habitats. Presence of invasive Rhododendron were also newly recorded and would require further monitoring and management. The Northern Plot features a higher diversity of mammals, including the presence of Red Squirrels, a priority conservation species that could benefit from the .

In summary, the Northern Plot is recommended for commercial forestry development due to its potential benefits to the prioritised Red squirrels, higher bird abundance of least concerned species, the presence of invasive species that could be managed through forestry, and the lack of SSSI status, which provides more flexibility in management decisions. This recommendation aligns with the need to balance economic development with ecological conservation, preserving the sensitive Southern Plot for its ecological significance and unique biodiversity

1. Introduction

1.1 Project background

This technical document presents a comprehensive Ecological Impact Assessment (EcIA) of two plots (see Fig. 1) located at Lochranza on the Isle of Arran in the Firth of Clyde, Scotland, which are under consideration for commercial forestry developments. The primary objective is to identify and evaluate the potential ecological impacts of the proposed development on these plots.

Forestry plantation provides important ecological services such as carbon sequestration by acting as a carbon sink, capturing and storing carbon dioxide from the atmosphere, thus contributing to climate change mitigation. The Climate Change Committee (CCC) advised an increase in UK tree cover from 13% of the UK's land area to 17% as part of the ongoing efforts to achieve net zero carbon emissions by 2050 (Climate Change Committee, 2020). Additionally, sustainably managed forests support biodiversity, offering habitats for various species, and can play a role in water regulation and soil conservation.

This assessment is based on a one-week ecological survey involving a comprehensive analysis of the diversity of plants, vertebrates, and invertebrates, which established the current baseline conditions of the ecosystems in the proposed plots. The findings from this survey are crucial for understanding the current baseline ecosystem conditions and for predicting how the proposed development might alter it. The findings and conclusions drawn from this survey will be instrumental in making an informed recommendation for the most suitable location for commercial forestry. In addition to that, this assessment will also propose necessary mitigation strategies to minimise the ecological footprint of such developments. These recommendations will be based on a thorough understanding of the ecological characteristics of the proposed plots and will aim to balance development needs with landowner's demand for sustainable development, minimising the impact on the diversity of plants, vertebrates, and invertebrates.

1.2 Site description

The two proposed plots (see Fig. 1) are located at Lochranza on the Isle of Arran in the Firth of Clyde, Scotland. The Northern plot is a 75 hectares plot consisting of a South-facing hillside and a relatively flat area on the top of the hillside. The Southern plot has an area of 70 hectares and consists mainly of a North-facing hillside. The two plots together form a natural valley and is separated by a main road, pastures, campsites, golf course, and a distillery, with a flowing water connected to the sea to the west of the two plots.

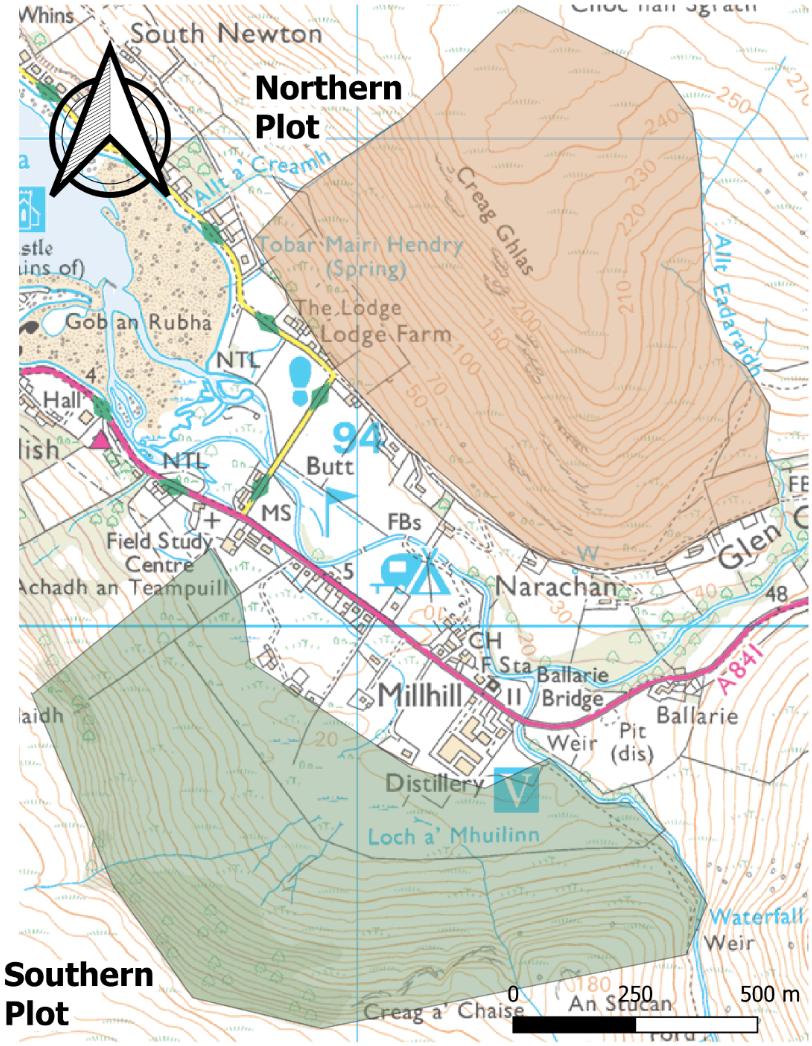

Fig.1: Map showing the two proposed plots for forestry development (Northern Plot on the top, Southern Plot at the bottom).

1.3 Focused Taxa

Given the constraints of limited time and resources, our focus was strategically narrowed to certain taxa that are both representative of the ecosystem and relatively easier to sample. These included plants, birds, mammals, and invertebrates. While amphibians, reptiles, and fish were observed within the proposed plots, they were excluded from detailed study for specific reasons that we will later elaborate upon.

Plants are one of the taxa which the landowner was particularly interested in, they also provide the foundation of habitats and allow us to identify different habitat types, which is essential for evaluating the potential impacts of forestry development. Despite our basic understanding in plants, we identified the key species on site which allowed us to classify the habitats into different types, and any vulnerable/protected species and invasive species, showcasing our commitment to a thorough survey given our limited expertise. Our survey on plants was limited to a Phase I Habitat Survey due to the limited expertise in our team and a further and more in depth survey by experts in the future is therefore recommended for a more comprehensive and accurate assessment of the local plant diversity.

Birds are one of the key taxa we focused on in our Ecological Impact Assessment due to several unique characteristics that make them ideal indicator species of diversity. Firstly, birds are generally easier to identify down to the species level, often distinguishable by their distinct calls, making them a particularly accessible group for surveying. This ease of identification allows for the effective detection of protected species, which is crucial in determining the ecological significance and regulatory compliances for the proposed developments. The ease of sampling most of the expected bird species in a particular area also allowed for the built up of species accumulation curve relatively quickly, which is a critical indicator of the adequacy of survey in its representativeness of the specific area.

Our desk-based survey also identified birds as the largest predator presence at the two proposed plots, further emphasising the ecological significance as important ecosystem regulators. Assessment on their population dynamics would provide valuable insight into the baseline health and balance of the local ecosystem, making them a vital component in our ecological impact assessment.

Mammals are the other vertebrate taxon we focused on in our Ecological Impact Assessment besides birds due to their role as flagship species, contributing to sectors like tourism and agriculture through various ecosystem services. For instance, four of Scotland's Big Five, which can all be found on Isle of Arran, are mammals. This elevates their ecological and economical significance especially in terms of conservation efforts. The presence of protected mammals and bats species identified by our desk-based survey further emphasise the importance of mammals in our assessment. Additionally, the overpopulation of red deer had been suppressing natural regeneration and negatively impacting other wildlife, understanding their number and presence is crucial for effective management in order to maintain a balanced ecosystem.

However, the sampling of mammals presents some unique challenges.Their large home ranges and elusive nature, especially in the case of bats, make them difficult to sample and accurately identify, even with advanced equipment. Traditional methods such as small mammal traps not only have ethical concerns, but are subject to governmental licensing which our team currently lacks. Therefore, in this assessment, we relied on less intrusive methods such as camera traps and audiomoths, which minimised our impact on the mammals and their habitats while collecting data as efficiently and accurately with the equipment and licensing restraints we had.

Invertebrates are an efficient and accurate indicator of biodiversity as they are not only easy to sample but also play a pivotal role in the ecosystem as a key food source, influencing diversity across various trophic levels. Additionally, the freshwater invertebrates presence and species composition serves as a reliable indicator of water quality, making them particularly valuable in our Ecological Impact Assessment. The inclusion of both freshwater and terrestrial invertebrates allows for a comprehensive understanding of biodiversity, as they occupy diverse habitats ranging from aquatic to land environments. Additionally, their smaller home ranges, compared to larger species from other taxa, make them more localised and more manageable to sample and monitor within a specific area.

Yet their vast diversity and often subtle differences between species, pose a significant challenge in accurately identifying them down to the species level, often requiring specialised expertise and tools for precise identification. Despite this challenge, their overall contribution to understanding the local ecosystems makes them a crucial component of our assessment.

We chose to exclude amphibians and reptiles for several reasons. These taxa are highly sensitive to pollution, making them great indicators of habitat quality and provide important insights such as heterogeneity and connectivity of high-quality habitats. They also serve as indicators of various environmental conditions, such as sunlight and humidity. However, they are typically more active in spring and sometimes summer (Ruthven et al., 2002). They are challenging to sample, particularly out of season and without the correct equipment.

Similarly, fish were excluded from our assessment due to complexities in sampling. Fish sampling uses completely different protocols compared to other taxa and often requires specific permits, which adds to our logistical challenges. While fish were observed at the site, suggesting their presence in the ecosystem, comprehensive data collection was not feasible within the scope of our assessment.

Consequently, we determined that focusing on aquatic invertebrates as indicators of water quality would be sufficient at this stage, especially considering that aquatic habitats only constitute a small proportion of both of the proposed plots. However, we do recommend further surveys on aquatic habitats to gain a more complete understanding of these environments and the species they support.

2. Methods

2.1 Desk Based Survey

2.1.1 Designated sites and protected areas

The protected status of the two land areas and proximity to important protected areas were identified on NatureScot.'s SiteLink website (https://sitelink.nature.scot/home). Using the Map function on the website, we identified the protected status of the two proposed plots. We then search for the protected site on the website and locate relevant information on "Operations requiring consent", "Site management" and "Features".

2.1.2 Priority / protected and invasive species

The presence of protected, priority, or invasive species in the two proposed plots were examined and identified using the UK National Biodiversity Network's NBN Atlas (https://nbnatlas.org/). A .kml file of the site was imported into the NBN Atlas to search for biodiversity records within specific areas. In the area report, we identified the number and types of priority and invasive species in that area.

2.2 Phase I Habitat Survey

We conducted Phase I habitat surveys on both the Northern and Southern plots. Given the complexity and variety of plant species, and considering the limited expertise in botany within our team, we decided to focus on identifying key species crucial for habitat classification, along with vulnerable or protected species, and invasive species. This approach was facilitated by a desk-based survey prior to the field survey, ensuring that we could at least recognize these species in the field.

On site, we successfully identified these key species, which allowed us to classify the habitats into distinct types. We also made detailed target notes for any observed vulnerable or protected species, as well as invasive species. This detailed identification process was crucial for understanding the ecological characteristics of each plot.

We utilised GPS applications such as What3Words to mark precise location and altitude when encountering a change in habitat type during our sample for other taxa. This helped in tracing boundaries of different habitat types on QGIS later with reference to coordinates and contour lines.

The Phase I habitat survey for the southern plot was conducted as a collective effort, with all relevant team members working together. In contrast, for the Northern plot, the survey was collectively produced by team members who had previously visited the plot after discussing their observations. This approach allowed us to gather comprehensive data on the habitats within each plot, and ensured team members that did not have the chance to visit the Northern plot have are equally informed of the habitat composition in the Northern plot.

2.3 Additional Field Surveys

In our team of 12 members, the allocation of roles was strategically based on each member's expertise in different taxa, ensuring that the most knowledgeable individuals led specific aspects of the ecological survey. To enhance overall team competency and familiarity with various methodologies, we implemented a rotation system that rotated at least half of the members across different groups. This rotation was carefully planned to maintain at least one experienced individual in each group at all times to ensure consistency in methods and to pass on their knowledge to the new members of the group.

Adhering to safety protocols, we ensured that each group consisted of a minimum of two people. However, this requirement, along with the rotation system, introduced some limitations in terms of efficiency. To address this challenge, the rotations of groups were often opportunistic to maintain efficiency.

However, we deliberately restricted participation for some methods employed in our survey. For instance, the setup and retrieval of camera traps and audiomoths were consistently handled by the same individuals throughout the survey to minimise variability and potential bias in the data collection process, as consistency in handling and placement of these devices are crucial for obtaining reliable and comparable results. This calculated approach aims to balance efficiency, consistency, and expertise in our ecological survey.

2.3.1 Trees

Considering the limited expertise in plants within our team, we focused specifically on trees due to their relative ease and quickness in sampling and identification. To systematically survey the trees, three transects were selected at low, mid, and high altitudes across the plots. This stratified approach allowed us to capture a representative sample of the tree species present across different ecological zones.

For each transect, we conducted a 30-minute walk, which covered approximately 350 metres. This duration and distance were chosen to balance thoroughness with time constraints. Due to the hard-to-traverse terrain parts of the Southern plot were not covered by our transects. As we walked along each transect, we identified and tallied all tree species present within 20-metre of either side. This method ensured that we had a comprehensive understanding of the tree diversity along each transect line.

2.3.2 Birds

In our bird survey, we employed a combination of transect walks and point counts, both of which are standard, efficient protocols for bird sampling. These methods allowed us to identify major bird species quickly and build species accumulation curves. The mixing of visual and auditory observations expanded the scope of study and the combination of transect walks and point counts provided us with robust data on the bird species present, their abundance, and distribution within the plots, contributing significantly to our understanding of their population dynamics within the proposed development area.

2.3.2.1 Transect Walks

The transect walks were conducted using the same paths as our tree sampling, with two team members per transect, with one focusing on trees and the other on birds, maximising efficiency by sampling both taxa simultaneously while adhering to our safety protocols. We identified and tallied all bird species present within 20-metre of either side using binoculars for visual observations and the aid of Merlin Bird App for auditory observations.

2.3.2.2 Point Counts

Point counts complemented this approach. Stationary for 30 minutes at strategic locations, we recorded all birds seen and heard, discounting flyover species. This method was especially beneficial for detecting elusive birds with minimal disturbance. in the Northern plot, the point counts were conducted in the centre of the plot, while in the Southern plot, they were positioned in areas not covered by the transects to ensure comprehensive coverage of the area.

2.3.3 Mammals

Although trapping is an effective method for mammal sampling especially for smaller mammals, ethical and licensing limitations made the use of these traps challenging, leading us to opt for the more ethically sound camera traps and audiomoths for our assessment within the proposed development area.

2.3.3.1 Camera Traps

Camera traps were employed in our mammal survey due to their ease of use and non-intrusive nature. We selected three optimal deer tracks at each plot for the placement of these traps as the limited number of available traps meant random placement was not feasible. To minimise bias in the placements of these traps, the same team members were responsible for choosing what they considered the most optimal locations for trap placement of all our sampling events at both plots. Efforts were made to vary the trap locations along different trails, with a minimum distance of 50 metres between each camera trap to avoid overlapping coverage. The traps were strategically positioned in areas free of obstructive vegetation, often hanging on rocks or bushes to ensure clear visibility.

Three camera traps were deployed on each site, which were left in the field for a 24-hour period and rotated between deer trails daily. The camera traps were set to motion-triggered picture capture with a one-minute delay. This setting allowed the camera to take a picture upon detecting motion and then enter a one-minute cooldown to minimise the chances of double counting the same individual. All the photos taken were then exported to a computer where all the photos taken were examined and mammals captured were all identified.

2.3.3.2 Audiomoths

Audiomoth was utilised to record bat activity, we recorded from 7:00 pm to 7:30 am based on known bat emergence times from our desk-based survey. The audiomoth was set to capture a wide frequency range, up to 192 kHz, to ensure all bat frequencies were recorded. The audiomoths were set to record for 300 seconds with 120 seconds intervals between each recording. The recordings were broken down into 300 seconds sections small enough to facilitate handling and analysis of the data, while at the same time long enough to reduce the likelihood of ending recording in the middle of a bat call.

As only 1 audiomoth was available, we had to rotate them between plots, and for a comprehensive survey of the bat population, we sampled a woodland habitat and an aquatic habitat at each plot. The Audiomoth was tied to trees in woodland habitats and placed in areas that were away from potential noise disturbances like streams in aquatic habitats, to ensure clear audio capture. For species identification, we used the "batdetect2" tool in Python Anaconda, which analyses call patterns and provides a probability score for each species detected. To focus on presence-absence data, we only considered the highest probability detection for each species at each site, setting a threshold of 0.5 to ensure the detections were not coincidental. If a species had a probability score of 0.5 or higher at a site, it was considered present there. Providing us with an understanding of bat activity and diversity within the proposed plots.

2.3.4 Terrestrial Invertebrates

Recognising the diversity of invertebrates and their varied habitats, we employed a combination of pitfall traps for ground-dwelling species and sweep-netting for species found on plants, allowing us to capture a comprehensive representation of the terrestrial invertebrate present in the area. Both methods are well-established and tried-and-tested in ecological surveys, and are easy to implement within a short time frame without the need for in depth expertise. Moth traps were originally considered to sample nocturnal invertebrates but were not carried out due to technical issues.

To systematically survey the terrestrial invertebrates, three transects were selected at low, mid, and high altitudes across the plots. This stratified approach allowed us to capture a representative sample of terrestrial invertebrates present across different ecological zones.

We employed separate transects for terrestrial invertebrates sampling and for birds and trees sampling. Due to time constraints, we had to perform sampling for these taxa simultaneously. The distinct transects for terrestrial invertebrates were strategically chosen to prevent any disturbance to the birds by sweep-netting, which could have affected the accuracy of the bird data.

2.3.4.1 Pitfall Traps

To sample the ground-dwelling invertebrates, pitfall traps were deployed. A systematic approach was implemented for the placements of pitfall traps, stopping every 5 minutes while walking along the transect. To maintain efficiency and avoid data skewness due to over-sampling in the same location, we alternated between sweep-netting and pitfall traps. Instead of stopping every 5 minutes, we stopped every 2.5 minutes during our transect walks and alternated between the two sampling methods. Each pitfall trap consisted of containers buried into the substrate, with the rim flush with the ground. 1 cm of soapy water was added to each trap to break the surface tension of the liquid, ensuring that any invertebrates that fell in could not escape, allowing for an efficient and effective sampling of ground-dwelling invertebrates.

Our initial goal was to place pitfall traps along all three transects. However, our sampling method was restricted to the part of the lower transect due to the challenging terrain including dense bracken, streams, that were too hard to traverse. Additionally, the difficult terrain posed challenges in setting up the pitfall traps, particularly in terms of digging. All these meant we were only able to sample part of the lower transect on both plots. The inclement weather, especially persistent rain while we were on site meant pitfall traps would be flooded, rendering them ineffective and leading to the decision to discontinue their use under such conditions.

2.3.4.2 Sweep-Netting

Sweep-netting was used to sample invertebrate species on plants to provide a more comprehensive representation of the invertebrate population in the two plots. 3 transects (Low, Mid, High) per plot based on altitude to ensure diverse ecological representation. We stopped to sample every five minutes during our transect walk. For each sampling event, we performed eight sweeps on each side within a 1 metre square area. We aimed to cover the length of the entire plot wherever feasible, trying to maintain the same altitude throughout each transect.

During each sweep-netting event, we recorded all the invertebrates captured and endeavoured to identify as many of them as possible, with the exception of ticks as they were hard to remove from sweep nets and present throughout all the sampling events.

2.3.5 Aquatic invertebrates

2.3.5.1 Kick Sampling

We employed kick sampling for aquatic invertebrates, selecting one optimal stream in each plot for this purpose. On each stream, we conducted a single transect, moving upstream for about 100 metres, stopping to sample every 20 metres along the transect. In the Northern transect, two team members performed kick sampling for three minutes at each site. The presence of rocks at the stream in the Southern transect created a slightly different habitat. To capture a full representation of the aquatic invertebrates population, we reduced the kicking time and had two team members perform kick sampling for two minutes at each site but also rubbing six rocks at each site to dislodge and capture more invertebrates.

After each sampling event, we emptied the contents of the net into a tray of water where we identified everything caught to order level and, whenever possible, to family level. Identifying these organisms to the species level would have required specialist equipment, which we did not have.

Similar kick sampling protocols were used for the marsh area in the Southern plot with slight changes to suit the habitat. The locations for sampling in the marsh were chosen opportunistically, with five sites on the left and five on the right. Due to the difficulty in traversing the marsh, we reduced the kick sampling duration to only 30 seconds at each site. However, the water in this area was very silty, which may have resulted in some invertebrates being missed in the sampling process.

2.3.5.2 Water Quality Assessment

Different aquatic invertebrates have different degrees of pollution tolerance, and with known information of their tolerance we can conduct a water quality assessment by scoring the body of water sampled. Their long aquatic life stages also mean they are good indicators of long term water quality. This allows us to systematically compare the water quality between the two plots. We opted to use the Biological Monitoring Working Party (BMWP) Score System and the Average Score Per Taxon (ASPT), widely used by water quality assessments in the (Hallawell, 1978).

All major aquatic invertebrate families have been assigned a BMWP score between 1 and 10 (see Appendix. 2), based on their sensitivity and tolerance to organic pollution, with the most sensitive families receiving the highest score. Once identified, the Indicator family was recorded. The scores for each family were then added to obtain an overall BMWP score for the sampling site.

However, the BMWP scores can vary not only due to water quality but sampling effort and diversity as well since it is a sum of the BMWP scores of all the families recorded. It can yield a relatively low score from sites that would be considered pristine if only a few indicator species of excellent water quality are present. The Average Score Per Taxon (ASPT) is therefore used in combination with the BMWP score. The ASPT score is a mean of the individual BMWP family scores recorded, making it less sensitive to sampling effort.

3. Results

3.1 Desk-Based Survey

3.1.1 Designated sites and Protected Area

Our desk-based survey on the status of the two proposed plots utilising information from NatureScot's SiteLink (2023), provided significant insights into the environmental designations and ecological characteristics of the Northern and Southern plots proposed for forestry development. Both plots hold the status of National Scenic Areas, indicating their aesthetic and ecological value. Additionally, they are situated near the Arran Moors Special Protection Area (SPA), which is crucial for the breeding of the Hen harrier (*Circus cyaneus*). This area is currently facing challenges such as habitat burning and the spread of invasive species like Bracken.

Fig.2: Map of the Arran Northern Mountains SSSI (Geographic Information Group, SNH, 2010).

A key distinction between the two plots is their designation under conservation statuses. The entire Southern plot, except for a small area of broadleaved parkland in the Northwest corner, falls within the Arran Northern Mountains Site of Special Scientific Interest (SSSI) (see Fig. 2). This designation signifies the Southern plot's ecological significance and its value for scientific study and conservation. Additionally, changes in tree and/or woodland management, including afforestation require consent from the Scottish Natural Heritage. In contrast, the Northern plot is not designated as an SSSI, presents fewer regulatory restrictions and possibly a lower level of ecological sensitivity compared to the Southern plot.

The Arran Northern Mountains SSSI that the Southern plot belongs to encompasses a complex ecological landscape with key features that are facing different challenges according to NatureScot's previous assessments. It includes a breeding bird assemblage, which is adversely affected by habitat burning and the invasion of Bracken. The upland habitat assemblage, the largest and most diverse of its kind in west central Scotland (Scottish Natural Heritage, 2011), shares similar threats such as habitat burning, the increased invasion of Bracken, and overgrazing. Additionally, the upland birch woodland, which is abundant in the Southern plot from our Phase I Habitat Survey, faces its own set of challenges including game and fisheries management practices, the invasive Rhododendron species, and overgrazing primarily by deer and sheep. It is important to note that the most extensive area of native birch woodland on Arran is found between Lochranza and Catacol (Scottish Natural Heritage, 2011), including the area within our Southern plot. The presence of these diverse ecological features and associated challenges in the Southern plot, particularly its status as part of the Arran Northern Mountains SSSI, emphasised its ecological complexity and the need for careful consideration in any development plans.

3.1.2 Priority / Protected and Invasive Species

Spatial searches on NBN Atlas showed that there are 7 invasive species within the spatial extent of the Northern Plot, including the Common Kestrel (*Falco tinnunculus*) recorded in the high bird transect in the Northern Plot. 5 invasive species were reported within the spatial extent of the Southern Plot, including the Common Rhododendron (*Rhododendron ponticum*) we recorded on the low tree transect in the Northern Plot instead. RSPB priority species and Biodiversity Action Plan UK list of priority species were used in conjunction to identify 4 distinct priority species in the Northern Plot and 11 in the Southern Plot. These priority species include the Common Toad (*Bufo bufo*) and the Red Squirrels (*Sciurus vulgaris*) recorded during this ecological impact assessment. For the full record of the searches, see Appendix. 1.

Out of all the priority and invasive species we identified from the desk-based survey, the status of the Red Squirrels (*Sciurus vulgaris*) on Arran presents an intriguing ecological scenario, being a priority protected species and invasive at the same time. This unique status is the result of the Arran Red Squirrel Project established in 2013, funded by the People's Trust for Endangered Species and Forestry and Land Scotland, and led by the Royal (Dick) School of Veterinary Studies, Edinburgh (Forestry and Land Scotland, 2020). This project aims to create a stronghold on the Isle of Arran for the Red Squirrels as Isle of Arran, unlike many other parts of the UK does not have the invasive Grey Squirrels, which has significantly contributed to the decline of the Red Squirrel population in mainland Britain. The absence of grey squirrels on Arran has allowed the red squirrel population to thrive without the intense competition and threat of disease typically brought by grey squirrels.

3.2 Phase 1 Habitat Survey

3.2.1 Maps

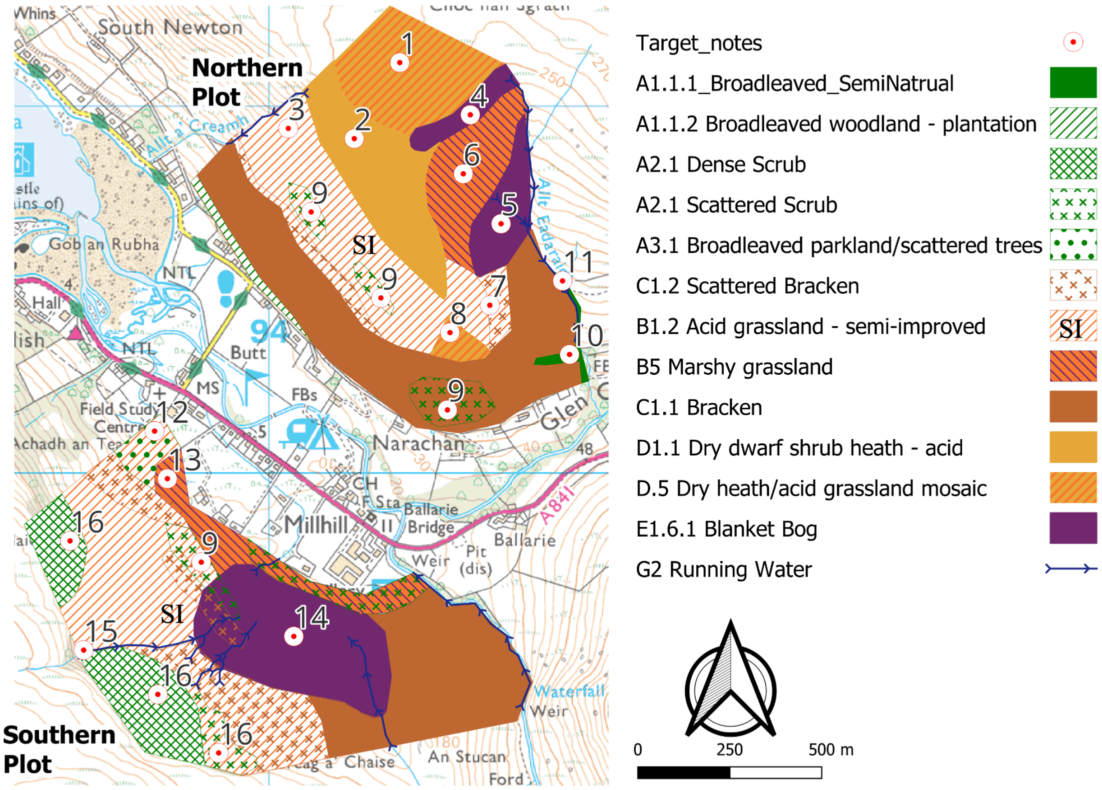

Fig.3: Phase I Habitat Survey of the two proposed plots.

3.2.2 Target Notes

3.2.2.1 Northern Plot

1. Bell Heather (*Erica cinerea*) Common Heather (*Calluna vulgaris*) and *nardus stricta* present.
2. Bell Heather (*Erica cinerea*) Common Heather (*Calluna vulgaris*). Common Frog (*Rana temporaria*) spotted there. Small peat sinkholes were also spotted.
3. Common Ragworts (*Jacobaea vulgaris*) spotted with Rowan (*Sorbus aucuparia*) at the opposite side of the stream close to the western boundary of the plot.
4. Many small invasive Rhododendron (*Rhododendron ponticum*) shrub and sapling spotted scattered across this blanket bog.
5. Dominated by *Juncus effusus* with abundant *Sphagnum spp.*
6. Over 50% of *Juncus effusus* with bracken and some *Sphagnum spp.*
7. Mostly Bracken with some Gorse (*Ulex europaeus*).
8. Large area of heather scrubs scattered across semi-improved acidic grassland.
9. Gorse (*Ulex europaeus*) scrubs.
10. Rowan (*Sorbus aucuparia*) woodland by the stream.
11. Likely an oligotrophic water, substrate rocky, sandy, water very clear, with Bryophytes present.

3.2.2.2 Southern Plot

9. Gorse (*Ulex europaeus*) scrubs.
12. Wide range of broadleaved plantation present but not sampled in our tree transects.
13. Over 25% of *Juncus effusus* with bracken and some *Sphagnum spp.*
14. Unmodified Sphagnum-rich Bog.
15. Likely a Dystrophic water with *Sphagnum spp.* present.
16. Silver Birch (*Betula pendula*) woodland, a key feature of the Arran Northern. Mountain Site of Significant Scientific Interest (SSSI).

3.3 Field-Based Survey

3.3.1 Trees

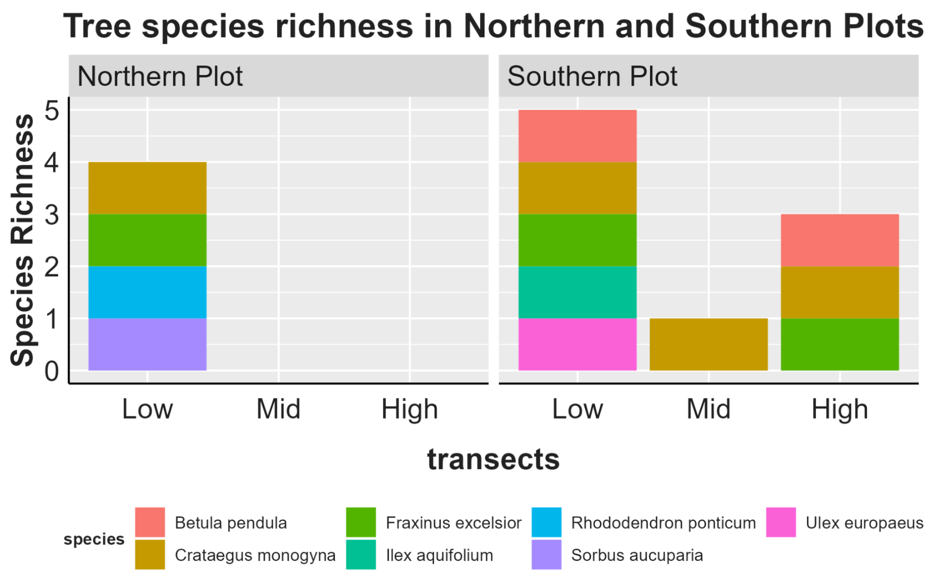

Fig.4: Tree species richness by altitude in the two proposed plots.

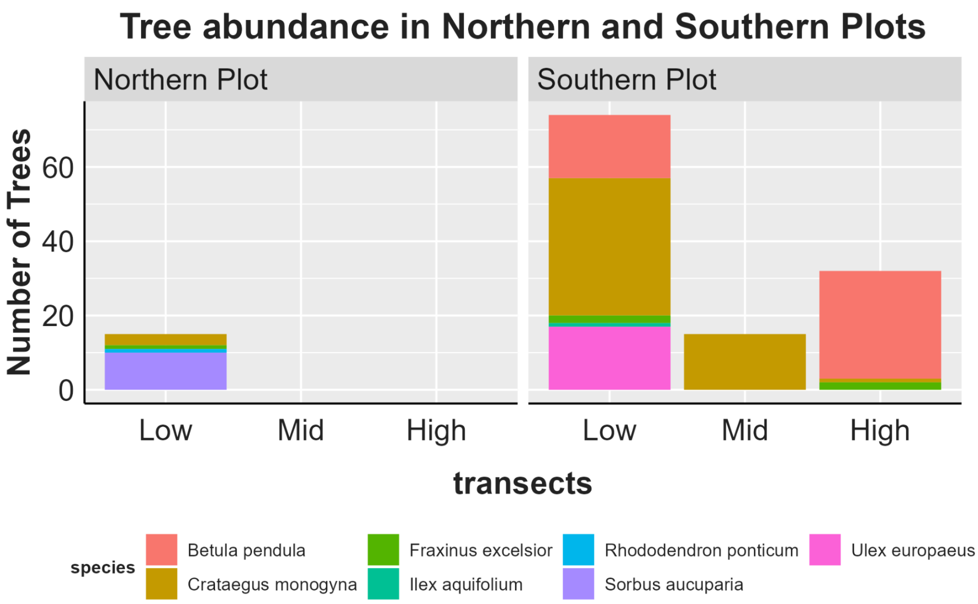

Fig.5: Tree abundance by altitude in the two proposed plots.

The Transects samples suggest tree species richness varies with altitude, with the low altitude transect showing highest species richness on both plots and the Southern plot showing higher richness at each transect compared to the Northern Plot (see Fig. 4). Tree abundance, like species richness, varies with altitude, with the low altitude transect again showing highest abundance on both plots and the Southern Plot again showing higher tree abundance at each transect compared to the Northern Plot (see Fig. 5).

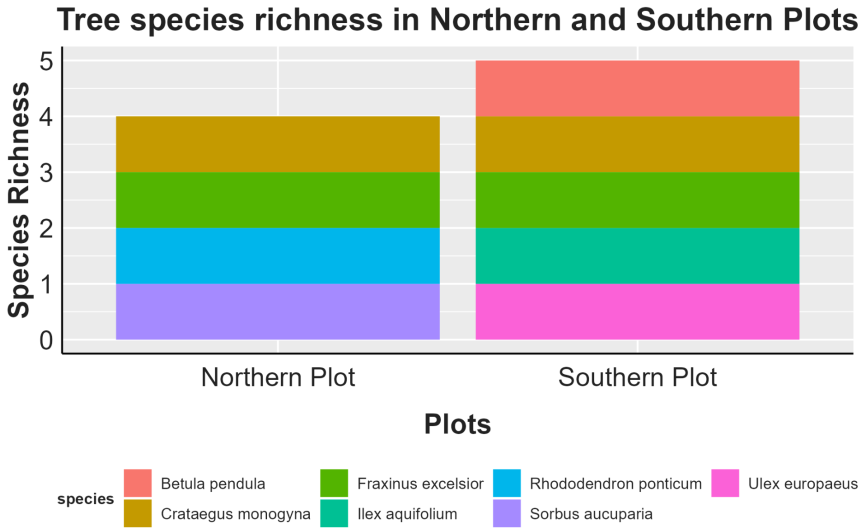

Fig.6: Tree species richness in the two proposed plots.

The total species richness of trees on both plots are very similar, the Southern Plot is slightly richer in species, with five species present compared to the four species in the Northern Plot (See Fig. 6). For species composition, Gorse (*Ulex europaeus*) were not sampled at any of the Northern transects. However, it is important to note that they were identified and were present at other parts of the Northern Plots according to our Phase I Habitat survey. Common rhododendron (*Rhododendron ponticum*), an invasive species is also present only on Northern Plot, while Silver Birch (*Betula pendula*) is present only in the Southern Plot, and is a key feature of the Arran Northern Mountains SSSI Southern Plot belongs to currently under negative pressure of overgrazing and invasive species like *Rhododendron ponticum*.

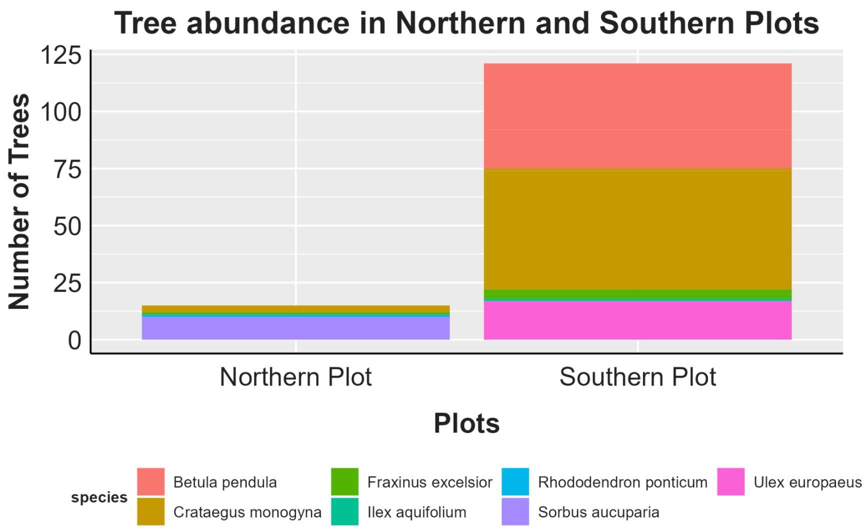

Fig.7: Tree abundance in the two proposed plots.

Despite the similar level of species richness, the Southern Plot has a significantly higher abundance of trees across all species, with Common Hawthorn (*Crataegus monogyna*) being the most abundant, followed by Silver Birch (*Betula pendula*) and Gorse (*Ulex europaeus*), both of which only sampled in the Southern Plot during the transect walks. The Northern Plot has a very low abundance of trees, with Rowan (*Sorbus aucuparia*) being the most represented species, although still in much smaller numbers compared to any species in the Southern Plot. The invasive *Rhododendron ponticum* which from our desk-based report were an invasive species found in the Southern Plot, was only sampled in transects in the Northern Plot and sighted shrubs and saplings of the species on top of the Northern hillside.

These results suggest that the Southern plot has both a greater diversity and a significantly higher abundance of tree species than the Northern Plot. Silver Birch (*Betula pendula*) were only present in the Southern Plot and were abundant. They are a key feature of the Arran Northern Mountains SSSI, and the Silver Birch woodland in Lochranza is the largest on the Isle of Arran. This key feature however, is under negative pressure of the invasive *Rhododendron ponticum*. Our results therefore suggest the Tree population in the Southern plot holds a more ecological significance. Providing vital information for the change in woodland management and the subsequent felling and afforestation proposed forestry development.

3.3.2 Birds

3.3.2.1 Transect Walks

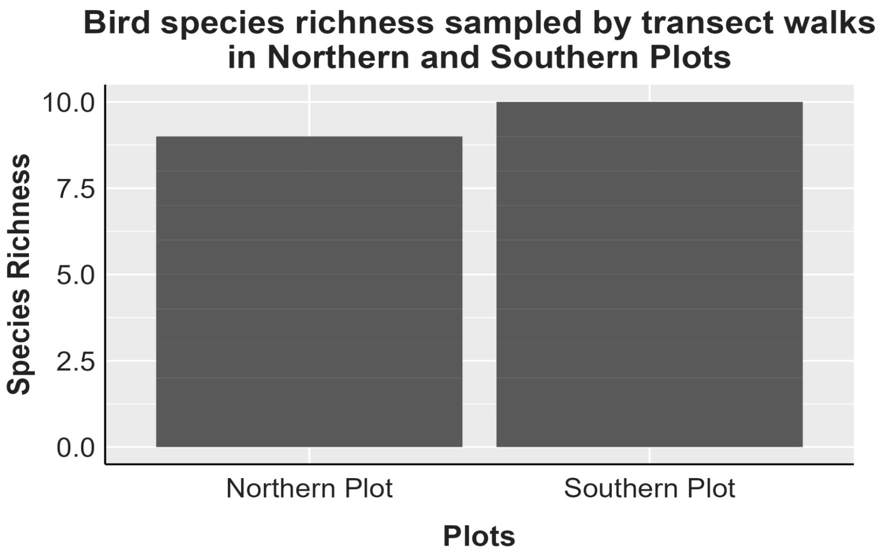

Fig.8: Bird species richness sampled by transect walks in Northern and Southern Plots.

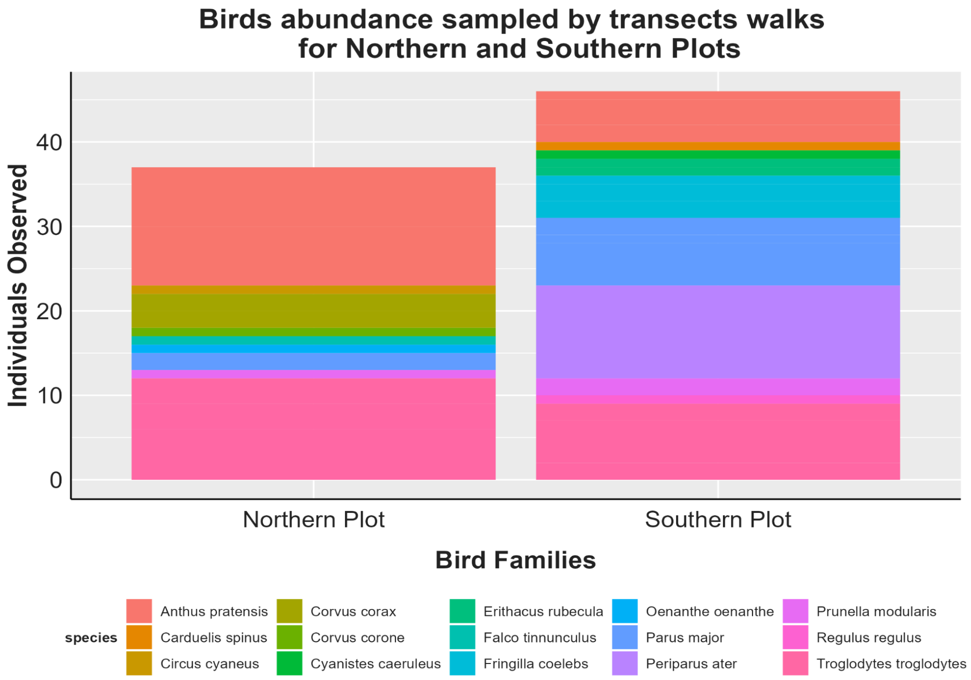

Fig.9: Bird abundance sampled by transect walks in Northern and Southern Plots.

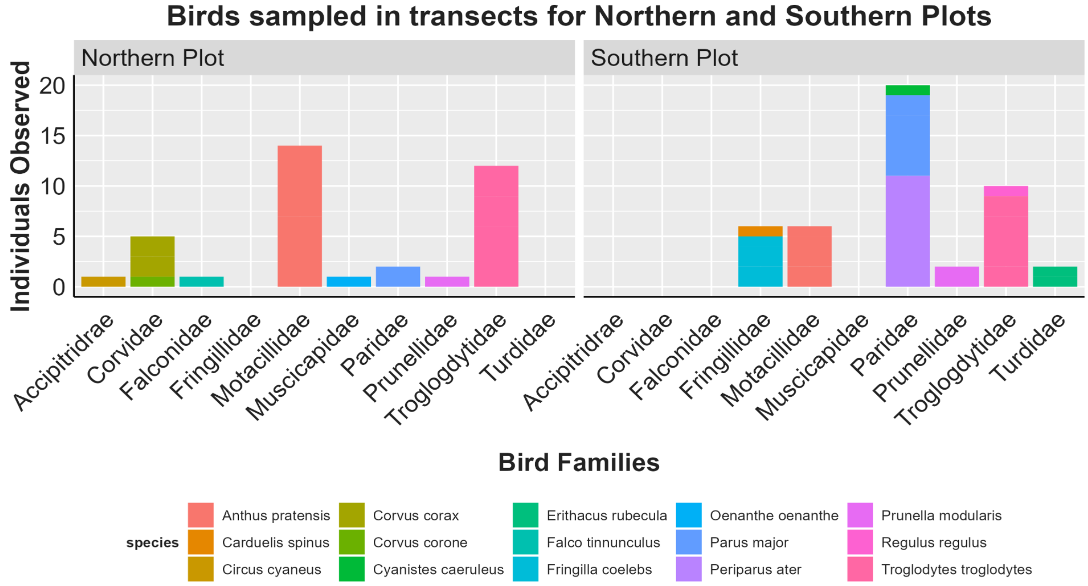

Fig.10: Birds abundance sampled by transect walks for Northern and Southern Plots by Family.

The graphs comparing bird data collected by transect walks between plots suggest a slightly higher bird species richness (see Fig. 8) and a higher individual abundance (see Fig. 9) in the Southern Plot compared to the Northern Plot. The Northern Plot shows a wider variety of bird families, with a particularly high number of individuals from the *Motacillidae* and *Troglogdytidae* families (see Fig. 10). In contrast, the Southern Plot has fewer families, with its highest abundance in the *Paridae* family (see Fig. 10). It is also important to note that two Common Kestrel (*Falco tinnunculus*), which is classified as an invasive species from our desk-based survey, were recorded in the High transect in the Northern Plot. This species prefers open habitat such as grassland, heaths and marshland, all found on the higher section of the Northern Plot and can thrive in treeless habitat. All these data point towards a different avian community composition between the two plots, which is likely due to the habitat composition differences.

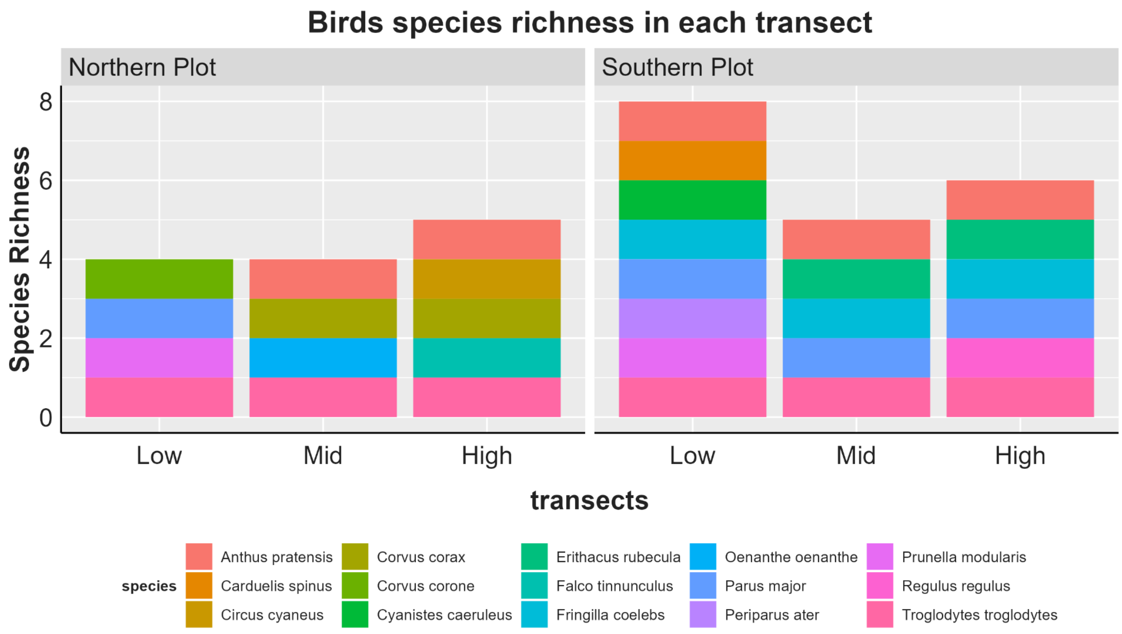

Fig.11: Bird species richness by altitude sampled by transect walks for Northern and Southern Plots.

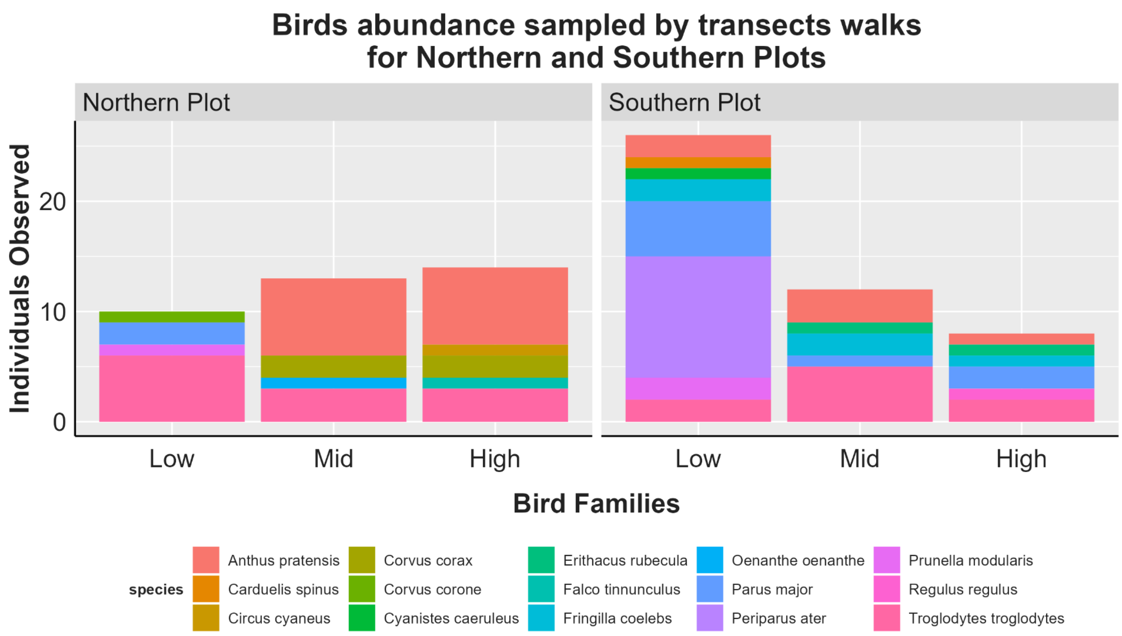

Fig.12: Birds abundance by altitude sampled by transect walks for Northern and Southern Plots.

When comparing the bird species richness and abundance between the two proposed plots at different altitude levels, both species richness (see Fig. 11) and abundance (see Fig. 12) are relatively consistent across altitudes in the Northern Plot. The Southern Plot, however, displays a significant increase in both richness (see Fig. 11) and abundance (see Fig. 12) at low-altitudes, particularly for Coal tits (*Periparus ater*). This suggests that altitude may influence bird distribution at least for the Southern Plot, with certain families preferring or thriving at specific altitude ranges within the Southern Plot.

3.3.2.2 Point Count

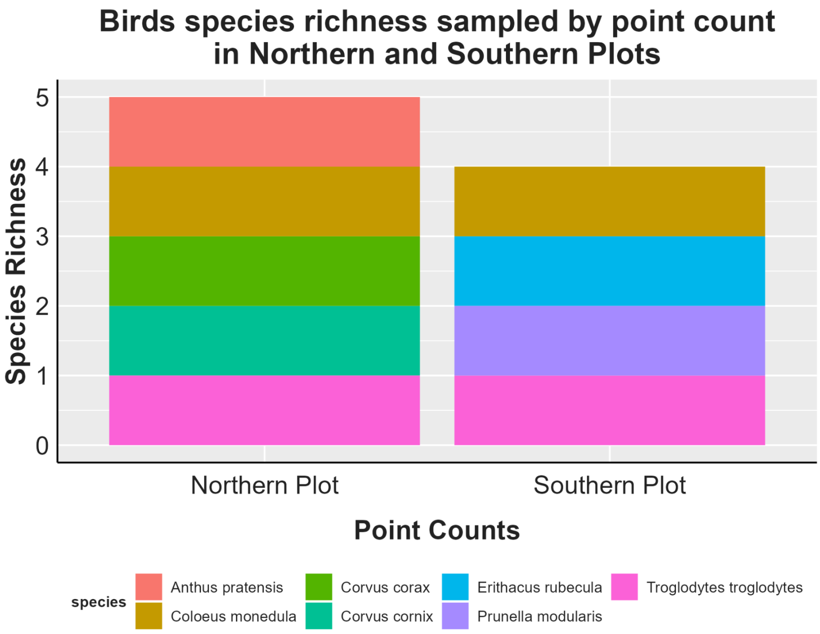

Fig.13: Bird species richness sampled by point counts in Northern and Southern Plots.

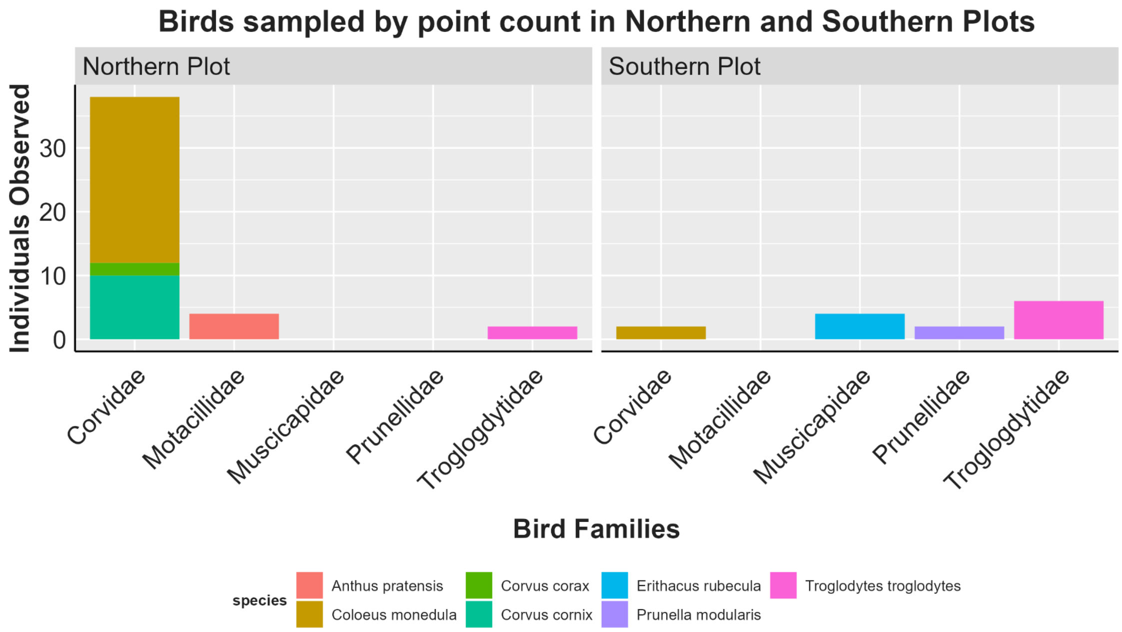

Fig.14: Bird abundance sampled by point counts in Northern and Southern Plots by family.

Contrary to our transect walks sample, our bird sample recorded by point counts exhibited a slightly higher species richness in the Northern Plot than in the Southern Plot (see Fig. 13). With Western Jackdaw (*Coloeus monedula*) and Wrens (*Troglodytes troglodytes*) present at both plots. The bird abundance recorded in the point counts were also higher in the Northern Plot (see Fig. 14) unlike data sampled transect walks. Birds from the family *Motacillidae* were only sampled in the Northern Plot point count, while *Muscicapidae* and *Prunellidae* were only sampled in the Southern Plot point count (see Fig. 14).

Prunella modularis is the only *Prunellidae* sampled in the Southern Plot. This species, along with *Muscicapidae* which is also only sampled in the Southern Plot are small arboreal insectivores that prefer wooded habitats from dense forest to open scrubs. In contrast, *Corvidae* which is significantly more abundant in the Northern Plot and *Motacillidae* birds are often ground feeders that prefer a more open habitat (Clancey, 1991). The difference in family composition further hinting at a difference in habitat composition in both plots.

3.3.2.3 Total

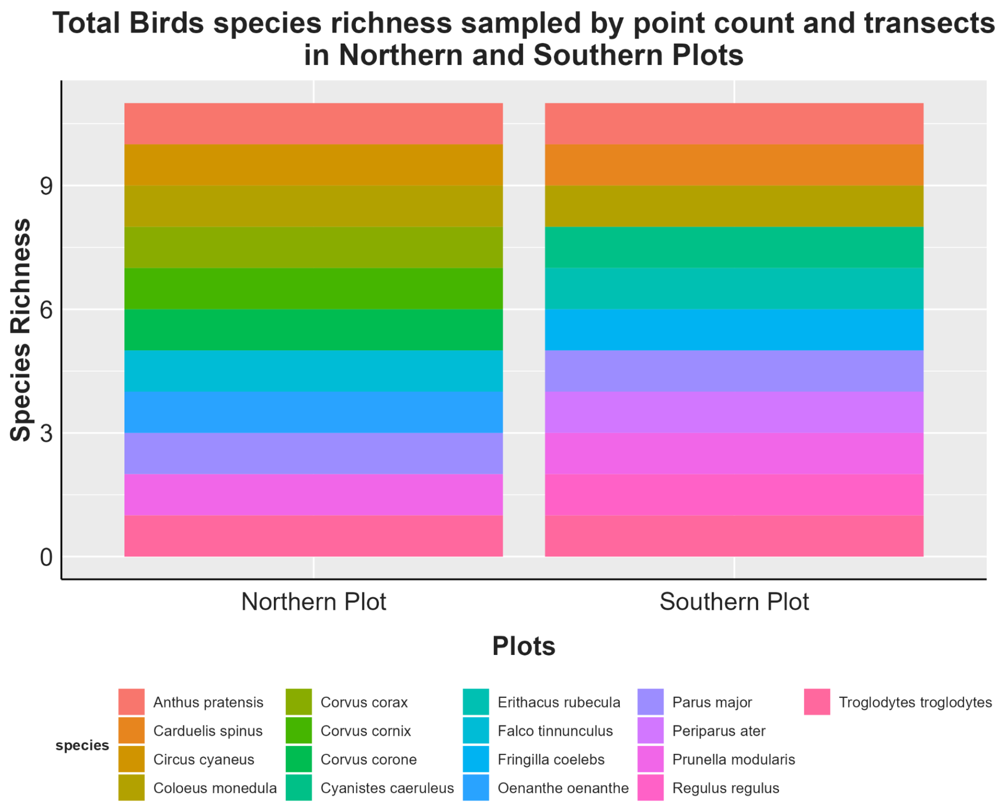

Fig.15: Total Bird species richness sampled in Northern and Southern Plots.

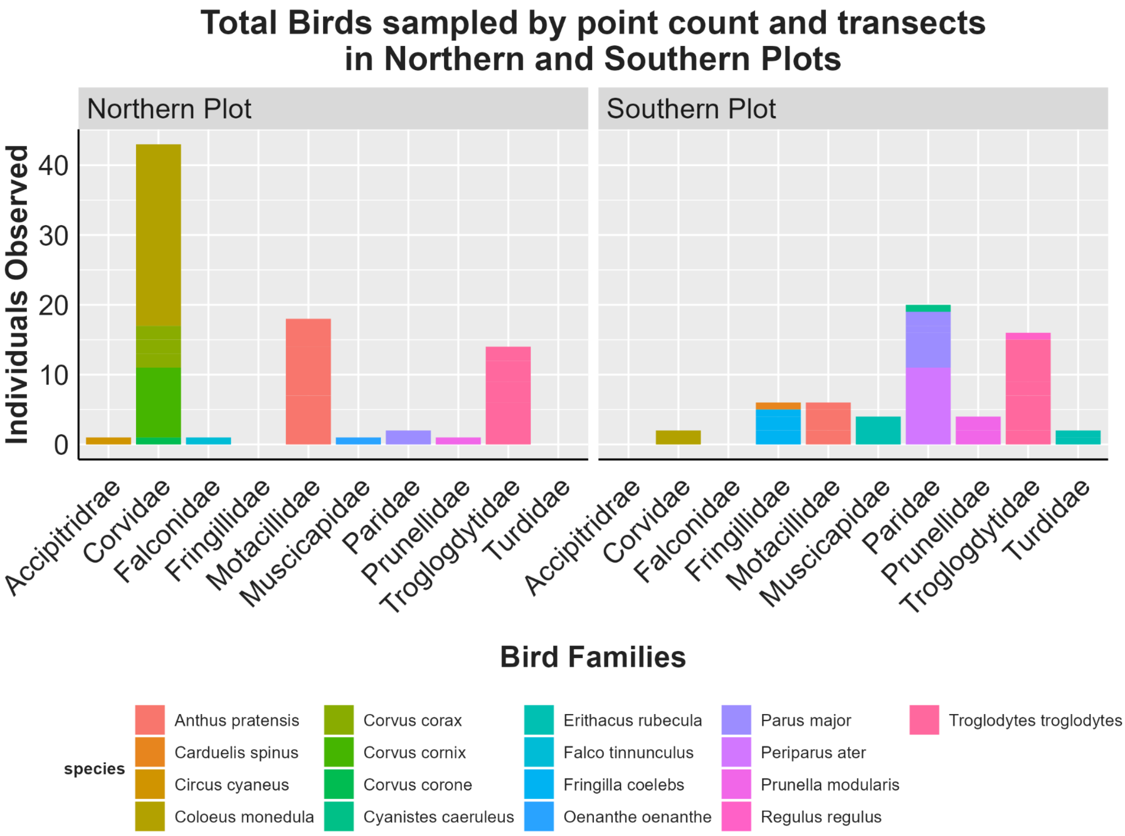

Fig.16: Total Bird abundance sampled in Northern and Southern Plots.

Overall, the species richness between the two sites are the same (see Fig. 15), both recorded 11 distinct species, but there are some notable differences in terms of their composition which could indicate differences in the habitat types between the two plots. This difference is further exacerbated when taken into account of the abundance of total birds sampled. The total abundance of Birds sampled was higher in the Northern Plot (see Fig. 16), where most of this difference came from the significantly higher population from the Corvids sampled by point counts (see Fig. 14). The Golden Eagle (*Aquila chrysaetos*), one of Scotland's Big Five were also notably recorded in both plots on many occasions throughout our survey and are reported in our incidental sightings (see Table. 1). This includes sampling events for our birds data but were excluded as they were flyovers and were likely not utilising the environment we were sampling in.

Although the Northern Plot showed a higher species richness and abundance in out point counts sample and a larger variety of families in the transect walks samples, the species abundance distribution of the Northern Plot is less even and is dominated by species from the *Corvidae* family, suggesting a less diverse overall bird community.

3.3.3 Mammals

3.3.3.1 Camera Traps

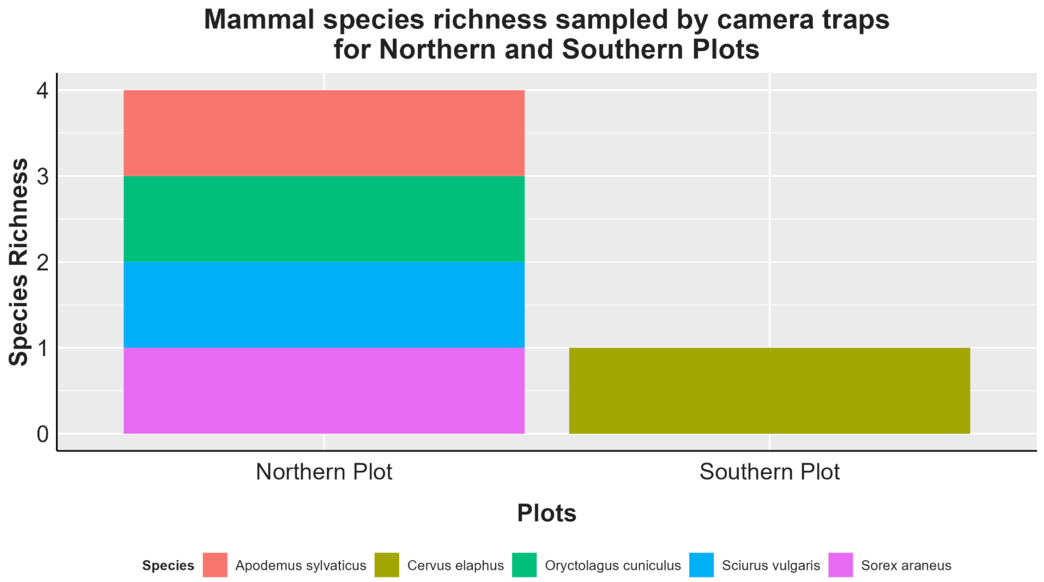

Fig.17: Mammal species richness sampled by camera traps in Northern and Southern Plots.

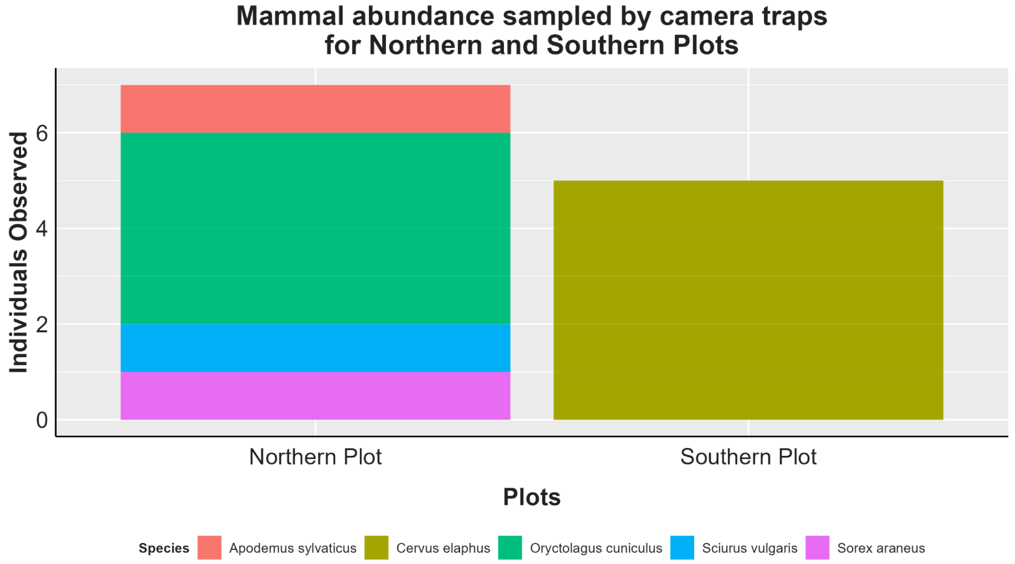

Fig.18: Mammal abundance sampled by camera traps in Northern and Southern Plots.

Camera traps set up in the Northern Plot showed higher species richness with a count of four different species, compared to the one in the Southern Plot (see Fig. 17), indicating a higher mammalian diversity within the camera trap's detection range. On the first night of sampling, 2 out of 3 camera traps in the Northern Plot encountered issues where one was obstructed by a fallen branch, and another was knocked over to the ground, resulting in a limited field of view. Notably, the Red Squirrels (Sciurus vulgaris), a priority and protected species identified by our desk-based survey, was captured by the knock over camera traps in the Northern Plot.

All four species of mammals recorded by the camera traps in the Northern Plot are small rodents and rabbits, while only red deer were recorded in the Southern Plot. Besides a higher species richness, the camera traps in the Northern Plot also captured a higher abundance in mammals (see Fig. 18), however, it is important to note that there we observed large number of Red deer during multiple occasions while conducting surveys for other taxa in the Southern Plot and they were recorded as incidental sightings (see Table. 1).

When considering the sample collected by the camera trap, it is important to note that camera traps are not equally effective in sampling all mammal groups under different habitat conditions and does not guarantee the detection of all individuals. The difference in species richness recorded could be a result of the habitat differences of the two plots. The dense vegetation in the Southern Plot compared to the relatively open grass and moorland in the Northern Plot meant small mammals are harder to be detected by the camera traps.

3.3.3.2 Audiomoths

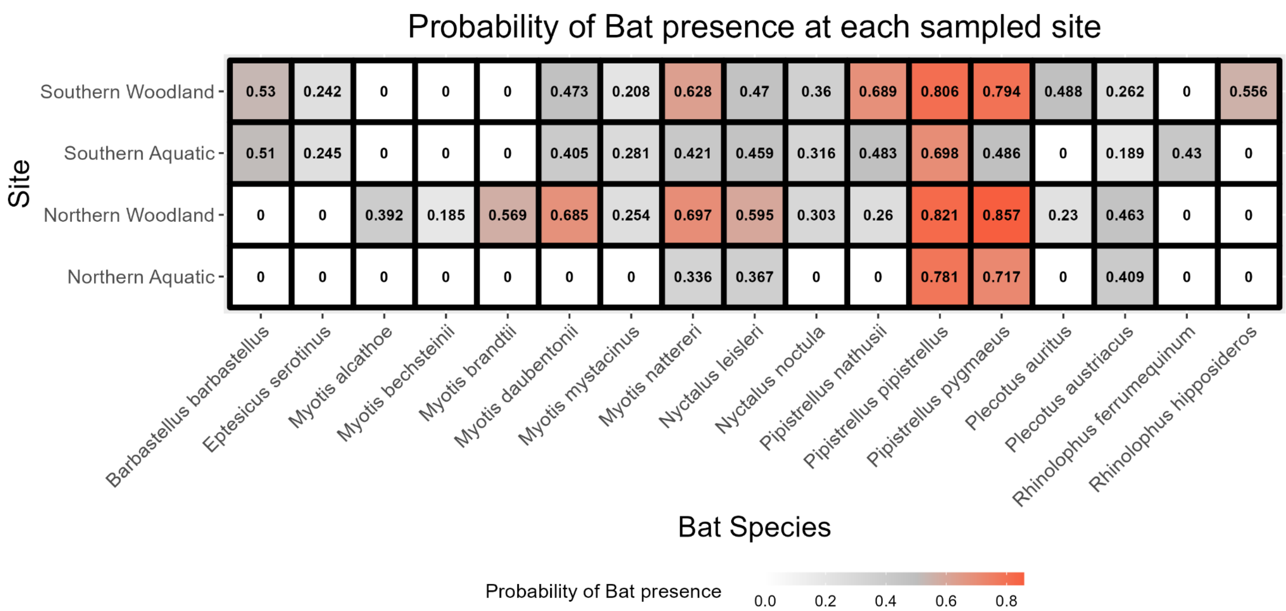

Fig.19: Heat Map showing probability of Bat presence per species at each sampled site.

A heatmap was created from the data sampled showing the probability of various bat species being correctly detected and identified across different sites in Northern and Southern woodlands and aquatic habitats. The colours used for the heat map range from white (0 probability) to red (high probability).

Most species show a higher probability of presence in the Northern Woodland sampling site, with Soprano Pipistrelle (*Pipistrellus pygmaeus*), Common Pipistrelle (*Pipistrellus pipistrellus*) and Natterer's Bat (*Myotis nattereri*) being the most likely to be present (see Fig. 19), all of which species we expected to find in the area from our desk-based survey. The Southern Woodland sampling site also shows a diverse presence, while aquatic sites generally have lower detection probabilities.

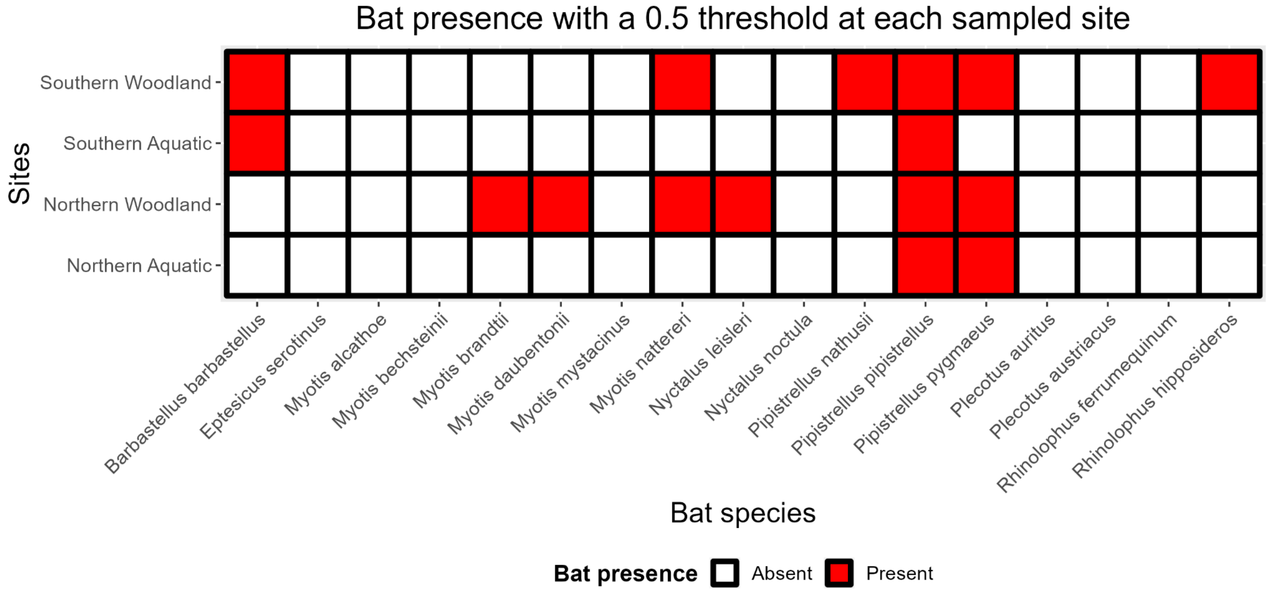

Fig.20: Bat presence per species at each sampled site at a 0.5 threshold.

When a threshold of 0.5 was implemented for the detection and identification probability, we simplified the data by only indicating presence (red) or absence (white). If a species had a probability score of 0.5 or higher at a site, it was considered present there.

This binary presence-absence map indicates that *Pipistrellus pipistrellus* were likely present across all of the sampling sites. *Pipistrellus pygmaeus* from the same genus were also likely present on most sampling sites except for the aquatic site in the Southern Plot. The woodland sites again had more present records compared to the aquatic sites (see Fig. 20). Suggesting the woodland habitats might provide more favourable conditions for bats compared to the aquatic sites.

As we were unable to determine the abundance of bats from the audiomoths recordings sampled, we can only compare the species richness between the Northern and Southern plots. Both plots have similar species richness, both recorded 6 species at the woodland sampling site and 2 species at the aquatic sampling site and a total of 6 species. The only difference being the 6 species sampled in the Northern sites are from 2 genus and the 6 sampled in the Southern sites are from 4 genus, suggesting the Southern plot might support a higher variety of bat species despite both plots having the same bat species richness.

3.3.4 Terrestrial Invertebrates

Due to time, equipment and expertise constraints, the identification of terrestrial invertebrates to the species level proved challenging during our study. Nonetheless, all data were accurately identified down to order level and, in 91% of cases, to family level. Identification to species level was conducted wherever feasible.

3.3.4.1 Pitfall Traps

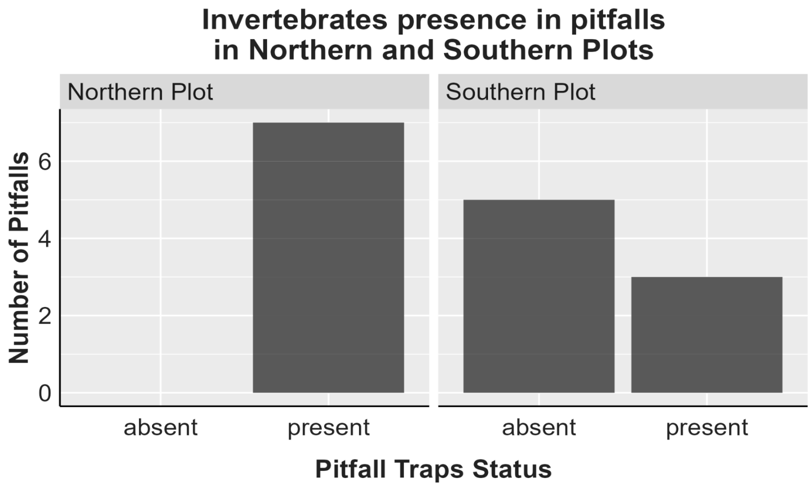

Fig.21: Terrestrial invertebrates presence in pitfall traps in Northern and Southern Plots.

7 pitfall traps were placed in the Northern Plot and 8 in the Southern Plot. Invertebrates were found consistently in all the pitfall traps placed across the Northern Plot while only 37.5% of the pitfall traps placed in the Southern Plot successfully captured invertebrates (see Fig. 21).

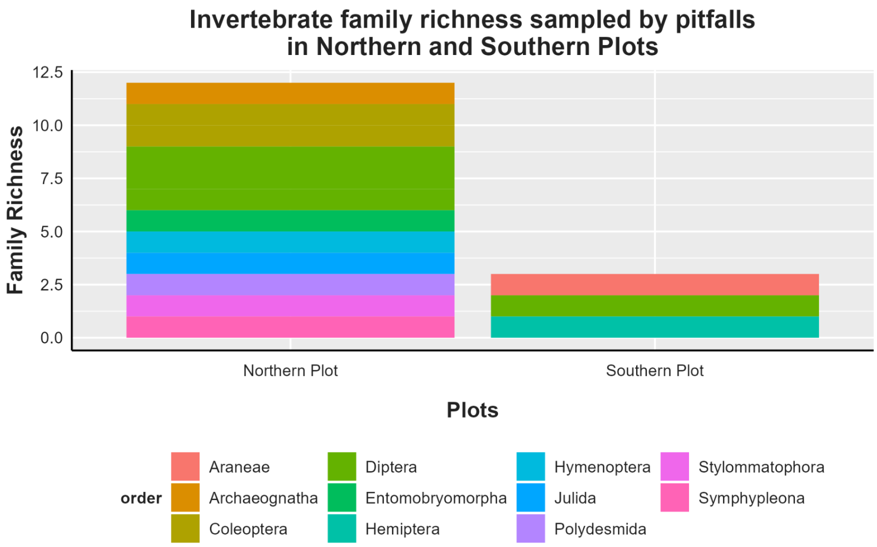

Fig.22: Terrestrial invertebrates family richness sampled by pitfall traps in Northern and Southern Plots.

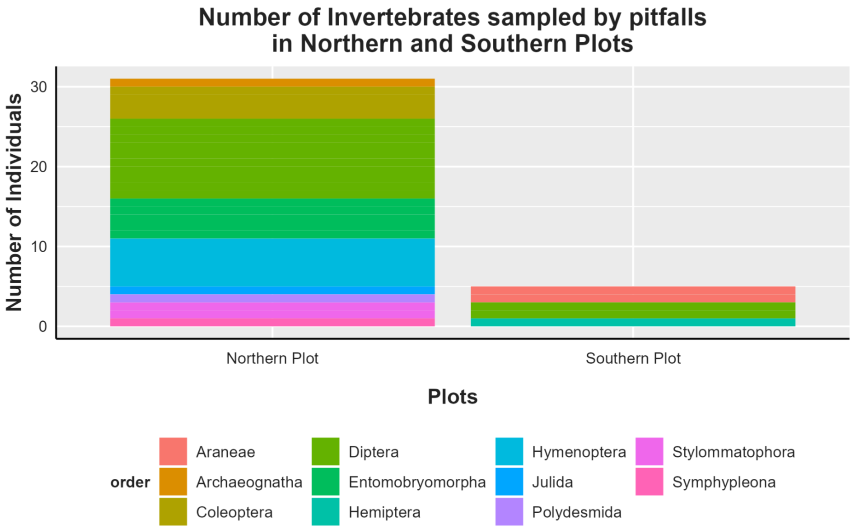

Fig.23: Terrestrial invertebrates abundance sampled by pitfall traps in Northern and Southern Plots.

The terrestrial invertebrates sampled by pitfall traps showed a significant difference in both family richness (see Fig. 22) and abundance (see Fig. 23) between the Northern and the Southern Plots. *Araneae*, *Diptera* and *Hemiptera* were the only 3 orders sampled by the Southern pitfall traps, while the Northern pitfall traps sampled *Araneae*, *Diptera* and 8 more orders that were not present in the Southern pitfall traps. All of these results suggest a possibly more active or abundant ground-dwelling invertebrate population in the Northern Plot.

3.3.4.2 Sweep-Netting

We sampled 18 times using the sweep-netting method on each plot. For the Northern Plot, we sampled 6 times in the low transect, 7 times in the mid transect and 5 times in the high transect. For the Southern Plot, we sampled 6 times in the low transect, 5 times in the mid transect and 7 times in the high transect. When considering the sweep-netting data, it is important to note that this subtle difference in sampling effort might slightly affect the accuracy of the data.

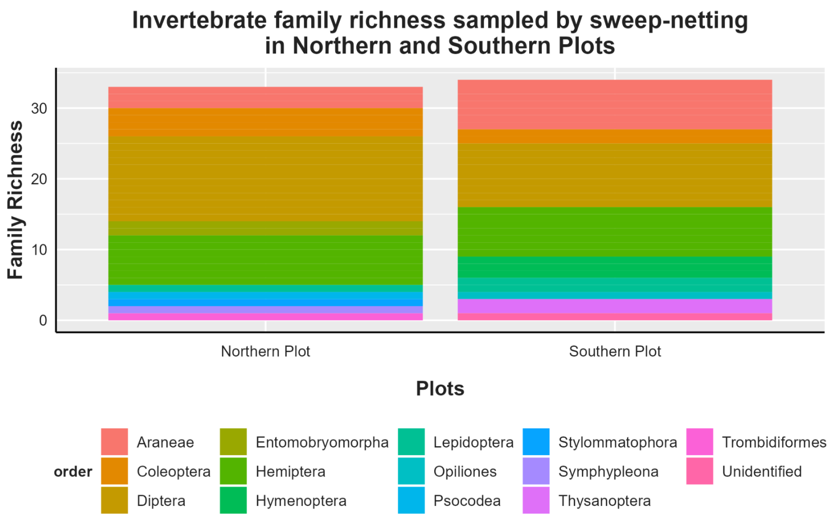

Fig.24: Terrestrial invertebrates family richness sampled by sweep-netting in Northern and Southern Plots.

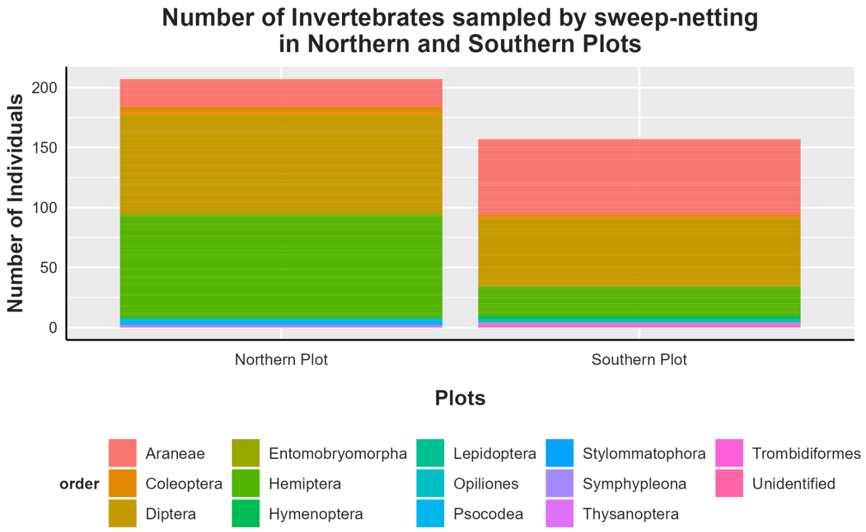

Fig.25: Terrestrial invertebrates abundance sampled by sweep-netting in Northern and Southern Plots.

The Sweep-netting results again showed a higher family richness (see Fig. 24) and abundance (see Fig. 25) of terrestrial invertebrates sampled in the Northern Plot compared to the Southern Plot, although the differences were not as significant. The results were dominated by orders such as *Araneae*, *Diptera* and *Hemiptera*, and most invertebrates in these orders likely lived above ground level, making them easier to be sampled using sweep nets, further emphasising the importance of right sampling technique for different groups of invertebrates.

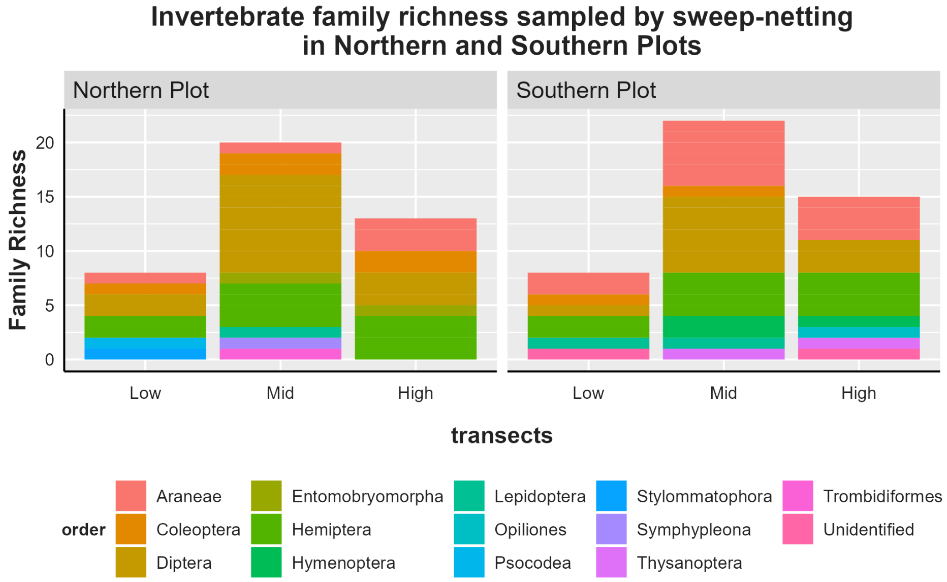

Fig.26: Terrestrial invertebrates family richness at different altitude transects sampled by sweep-netting in Northern and Southern Plots.

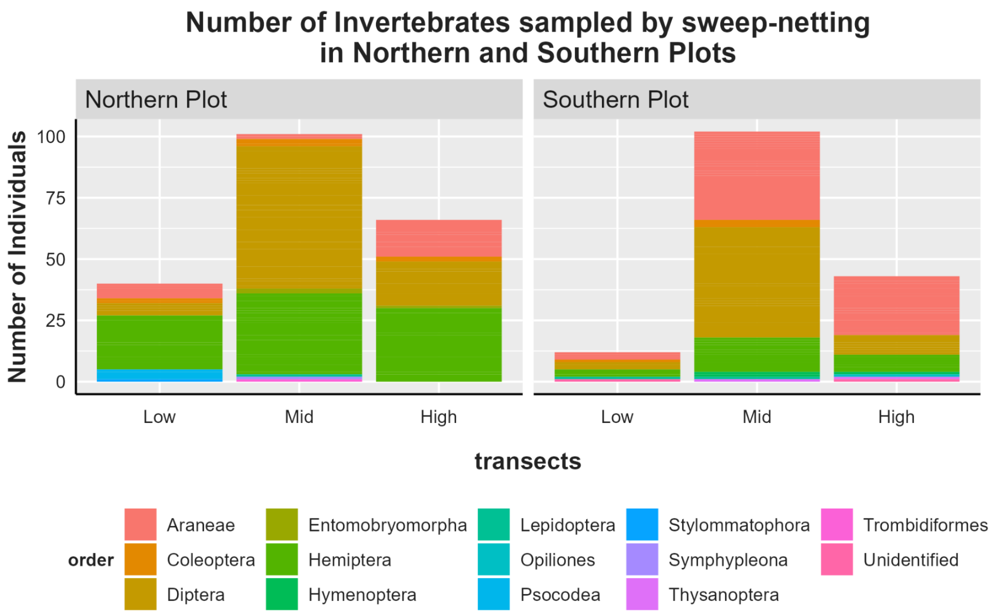

Fig.27: Terrestrial invertebrates abundance at different altitude transects sampled by sweep-netting in Northern and Southern Plots.

The family richness (see Fig. 26) and abundance (see Fig. 27) of terrestrial invertebrates sampled by sweep-netting showed similar trends between the Northern and Southern Plots, with a distinct variability between altitudes. The mid transects had the highest family richness and abundance within both of the Plots, while the low transects had the lowest family richness and abundance within their Plots. This could suggest that certain invertebrate families prefer specific altitude conditions.

However, when analysing the sweep-netting data across different transects at different altitude level, it is important to note that the habitat composition of these transects were also different, with both low transects in dense bracken habitat, both mid transects mostly covering semi-improved acidic grassland and the high transect in the Northern Plot covering Moorland and the high transect in the Southern Plot covering mostly Silver Birch woodlands. These differences in habitat could also contribute to the differences in terrestrial invertebrates family richness and abundance sampled at different transects.

3.3.4.3 Total

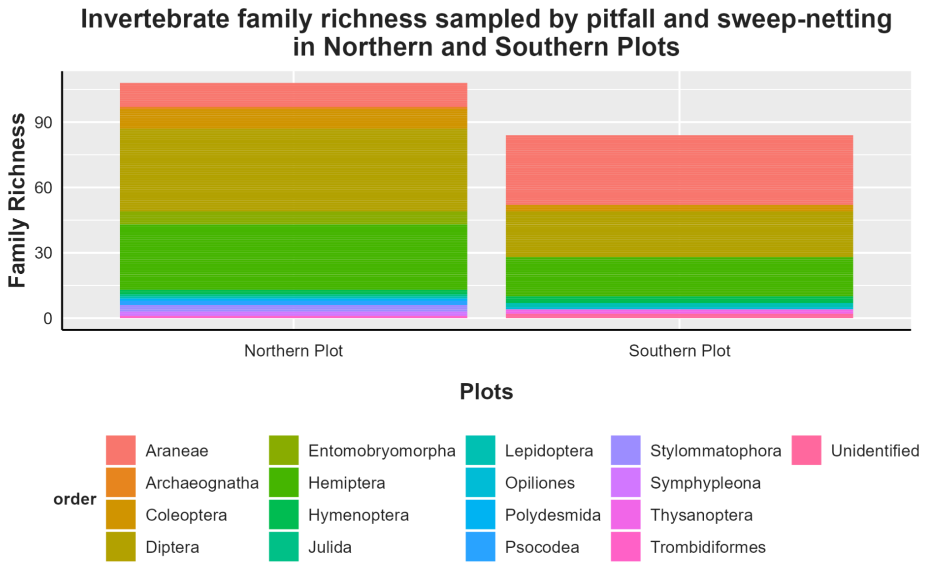

Fig.28: Total terrestrial invertebrates family richness in Northern and Southern Plots.

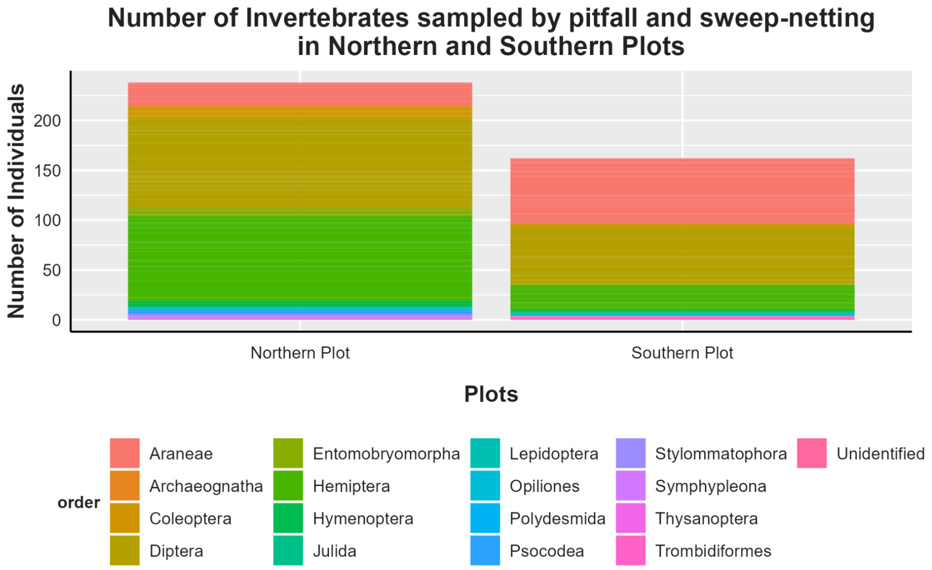

Fig.29: Total terrestrial invertebrates abundance in Northern and Southern Plots.

Overall, the combination of pitfall traps and sweep-netting revealed that the Northern Plot had greater terrestrial invertebrate family richness (see Fig. 28) and abundance (see Fig. 29) than the Southern Plot. This suggests that within the groups of terrestrial invertebrates that can be effectively sampled by these two methods, there is possibly a more complex invertebrate community structure in the Northern Plot than the Southern Plot.

3.3.5 Aquatic Invertebrates

3.3.5.1 Kick Sampling

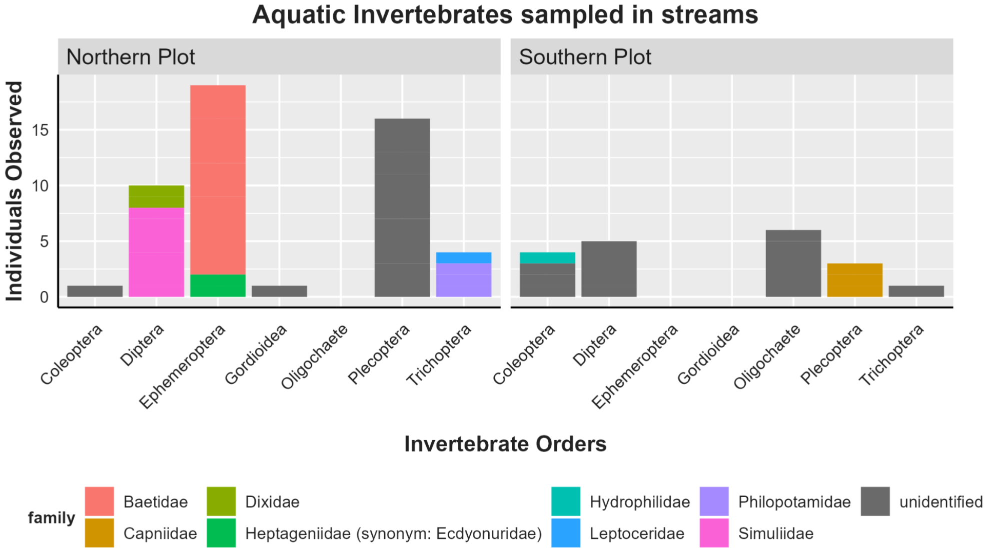

Fig.30: Aquatic invertebrates abundance sampled in streams in Northern and Southern Plots.

We sampled 5 times on each of the streams. The Northern Plot stream we sampled showed a significantly higher abundance of aquatic invertebrates observed, particularly within the *Ephemeroptera* order, which was absent in the Southern stream (see Fig. 30). This could imply more favourable conditions or a more complex habitat structure for such invertebrates in the Northern streams.

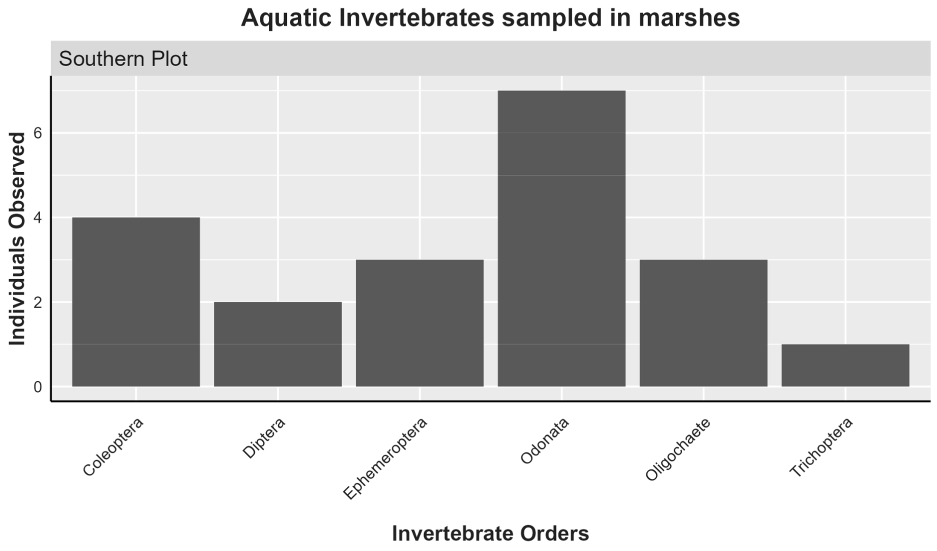

Fig.31: Aquatic invertebrates abundance sampled in the Southern Marshes.

We sampled 9 times in the Southern Plot marsh, and a variety of invertebrate orders were observed, with invertebrates from the *Odonata* order being most abundant and only observed in this habitat (see Fig. 31), indicating that dragonflies and damselflies are notably prevalent in these marsh habitats. Invertebrates from the *Ephemeroptera* order which were absent in the Southern Plot stream sampled were also recorded in the Southern marsh.

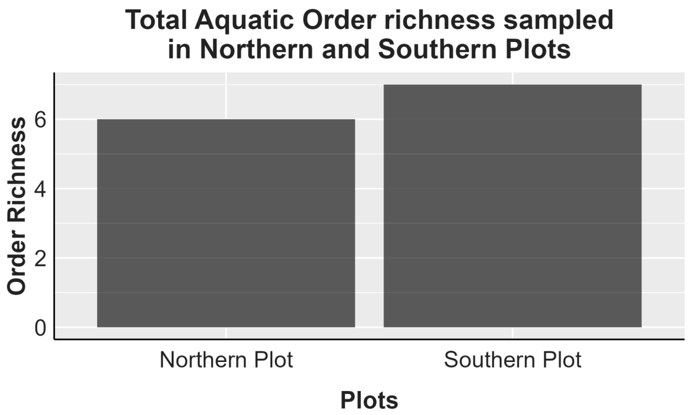

Fig.32: Total Aquatic invertebrates order richness in Northern and Southern Plots.

The total aquatic order richness sampled were similar between both Northern and Southern Plots, the Northern Plot having 6 and the Southern Plot having 7 (see Fig. 32). However, it is important to note that the sampling effort of the two plots were imbalanced, with 9 more samples collected in marsh for the Southern Plot.

3.3.5.2 Water Quality Assessment

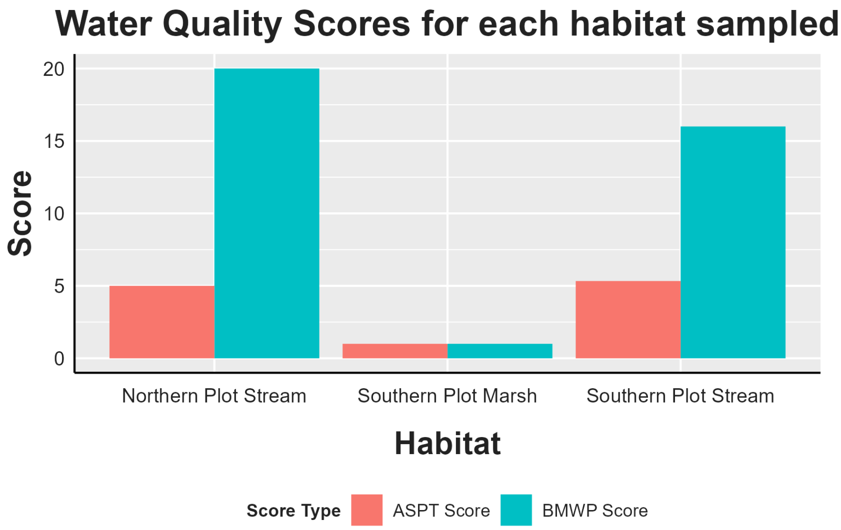

Fig.33: The Average Score Per Taxon (ASPT) and Biological Monitoring Working Party (BMWP) Score System Scores for each of the habitat sampled.

Due to the lack of appropriate tools and expertise for invertebrate identification, many of the aquatic invertebrates were only sampled to order level. As a result, we were unable to determine the scores for many recorded invertebrates and had to remove them from the water quality assessment, which greatly affected the accuracy of the scores obtained.

The BMWP scores obtained showed a higher score in the stream in the Northern Plot we sampled, compared to the two different bodies of water we sampled in the Southern Plot. The marsh habitat in the Southern Plot had a score of 1 for both the ASPT and BMWP scores, suggesting very poor water quality, while both streams sampled in the Northern and Southern Plots scored 5 or slightly above 5 in ASPT scores, suggesting excellent water quality (see Fig. 33).

3.3.6 Incidental Sightings

The Table below showed all of the incidental sightings recorded while surveying the two plots. Red Squirrels (*Sciurus vulgaris*), a priority and protected species identified by our desk-based survey, were sighted in the Northern plots. 3 of Scotland's Big Five (Golden Eagle, Red Deer and Red Squirrel) were repeatedly observed. It was also the second time Ring ouzel (*Turdus torquatus*) was recorded on Arran in 2023.

Table. 1: Records of all the Incidental Sightings recorded during our survey on site

Location/Nearest sampling ID	Date	Scientific Name	Common Name	Notes
Northern Plot High Birds Transect	12/09/2023	*Aquila chrysaetos*	Golden eagle	Flying overhead
Near Southern Plot Low Birds Transect	12/09/2023		Shed reptile skin (probably common lizard)	
Southern Plot Mid Birds Transect	13/09/2023	*Aquila chrysaetos*	Golden eagle	2 spotted flying near upper transect whilst being mobbed by crows
Southern Plot Mid Birds Transect	13/09/2023	*Cervus elaphus*	Red deer	Group of 7
Southern Plot 1st Pitfall	13/09/2023	*Tyto alba*	Barn Owl	Flying from the trees in the Southern Plot to one of the houses by the road
Southern Plot 8th Pitfall	13/09/2023	*Cervus elaphus*	Red deer	Heard at least one male deer
Southern Plot Mid Birds Transect	13/09/2023	*Cervus elaphus*	Red deer	Female with active fawn
Northern Plot Low Birds Transect	13/09/2023	*Sciurus vulgaris*	Red squirrel	2 individuals
Northern Plot High Birds Transect	13/09/2023	*Aquila chrysaetos*	Golden eagle	flying overhead
Northern Plot High Birds Transect	13/09/2023	*Falco peregrinus*	Peregrine falcon	hunting near plot
Southern Birds Point Count	14/09/2023	*Aquila chrysaetos*	Golden eagle	Flying over southern plot
Southern Plot 7th Pitfall	14/09/2023	*Cervus elaphus*	Red deer	A pair
Observation made from the southeastern edge of the northern plot	14/09/2023	*Aquila chrysaetos*	Golden eagle	2 individuals flying over towards the south eastern edge of the southern plot (eventually flew south over the hill of the southern plot)
Southern Birds Point Count	14/09/2023	*Corvus corone*	Carrion Crow	2 individuals
Southern Moorland	15/09/2023	*Bufo bufo*	Common toad	
Top of Northern Plot	15/09/2023	*Rana temporaria*	Common Frog	In the Heather
Northern Plot Mid Birds Transect	15/09/2023	*Turdus torquatus*	Ring ouzel	3 individuals flew east after perching on gorse in northern plot
Southern Plot Marsh	15/09/2023	*Rana temporaria*	Common Frog	In the marsh

4. Discussion

4.1 Identification of potential significant ecological effects

Forestry development, particularly afforestation, clearcutting and the construction of roads and landings for timber, can have significant ecological effects. These activities are often negative, leading to habitat loss, disruption of the baseline ecosystem balance, and consequently loss of biodiversity especially when implemented without consideration of the existing ecosystems. Furthermore forestry development could potentially cause erosion and pollute the excellent baseline water quality of the streams sampled in both plots.

As large areas of both proposed plots are waterlogged habitats, drainage of these habitats for forestry alters hydrological systems, affecting species adapted to such conditions. The extent of these impacts depends on the size of the development, and larger projects can lead to substantial habitat fragmentation. Such habitat losses are typically long-term and, in many cases, irreversible, as the construction of roads, skid trails, timber landings and other infrastructure for the extraction of timber leads to a fundamental alteration of the landscape. The construction and usage of these infrastructure would continue to disrupt the biodiversity through noise pollution as long as the commercial forestry is running. Their usage frequency and timing, especially if they were used during critical breeding or migration periods for sensitive species, would exacerbate their impact.

In terms of biodiversity, developments on the two proposed plots can have different implications to the different taxa surveyed. While both plots exhibit comparable diversity and abundance across most taxa except for mammals, birds and trees. For these particular taxa, the potential ecological impact of forestry development varies significantly between the Southern and Northern plots, each presenting unique characteristics and challenges.

The Southern Plot recorded a higher richness and abundance of trees, including a significant presence of Silver Birch woodland, a key feature of its ecological landscape and the Arran Northern Mountain SSSI the Southern Plot belongs to. Commercial forestry development in this plot could have a substantial impact on this tree diversity. Changes in tree species composition and density could alter the habitat structure, affecting species that depend on the woodland ecosystem. Bird diversity in the Southern Plot had a more even distribution of species abundance, suggesting a more diverse and desirable bird population. The birds sampled in the Southern Plot were mostly arboreal and live in woodland habitats with a smaller range, which means that they will be more sensitive to changes of woodland and the clearing and felling of the existing woodland that would come with forestry development plan in the Southern Plot. The potential impact on these bird populations could be significant, given their reliance on the existing woodland structure.

The Northern Plot has a larger bird population than in the Southern Plot but is dominated by species of least concern and invasive Kestrel that prefer open habitats. This could imply a lesser ecological impact of forestry development on the overall bird community. However, the presence of newly recorded invasive Rhododendron means careful management is required to prevent further ecological imbalance. The Northern Plot also features a higher diversity of mammals, including the presence of Red Squirrels, a priority conservation species. The potential impact of forestry development on these mammalian populations, particularly in terms of habitat modification and food availability, would require careful consideration to ensure their continued survival and prosperity.

Forestry development in the Northern Plot in particular, where Red Squirrels have been recorded as a priority species, can have a largely positive impact on the Red squirrel population, provided it is managed with their habitat preferences in mind. Coniferous trees typically used in forestry practices align better with the habitat needs of Red Squirrels over the broadleaved woodlands predominant in the Southern Plot. Implementing practices similar to those used in the Arran Red Squirrel Project, such as thinning trees to boost cone production, planting a variety of tree species, and creating corridors to connect existing forests, can significantly enhance the habitat and food availability for Red Squirrels. The extent of this positive impact again depends on the scale of the forestry development and the execution of these squirrel-friendly practices. Such forestry initiatives could lead to a substantial improvement in the quality and continuity of habitats for the Red Squirrels, with long-lasting effects if maintained properly. The frequency and timing of forestry activities like thinning should be carefully managed to continually support squirrel populations without causing undue disruption. While the positive impacts on Red Squirrel habitats are largely reversible, careful ongoing management is essential to ensure that these benefits are sustained over time.

4.2 Mitigation

4.2.1 Avoidance

Priority must be given to the conservation of high-value ecological resources, notably the streams within both Northern and Southern plots that both demonstrated excellent water quality, as evidenced by an ASPT score of 5 (see Fig. 33) as these aquatic systems are likely supporting a diverse and sensitive aquatic assemblage which constitutes a significant part of the local biodiversity.

Additionally, the development should strictly avoid areas of peat bogs. Peat bogs act as significant carbon sinks, and their disturbance could lead to the release of stored carbon, contradicting the development's objective of enhancing carbon sequestration. Afforestation on peat soils can lead to drying and oxidation of the peat, which not only releases carbon but the waterlogged, nutrient poor and acidic of peat bogs also means trees planted will likely not thrive in such environments. The moorland on the top of the Northern Plot in particular is a distinct habitat not found on the rest of the proposed area, and its distinction is further emphasised by the differences of the bird and invertebrate composition sampled by our Northern high transect compared to other transects (see Fig. 11 & 26). The Silver Birch woodland in the Southern Plot is also a major feature of the Arran Northern Mountains SSSI and developments on such habitat would require consent from the Scottish Natural Heritage and although possibly approved, should in general not be avoided for any developments that would further impact the already under pressure assemblage. Any forestry development in such habitats would likely be detrimental for the specialised and diverse flora and fauna present there. Instead, afforestation should target habitats that are commonly observed in both plots and surrounding areas as the ecological impact would likely be less adverse.

Priority and protected species were also recorded in our survey and there had been historical records of protected species presence in the area. The proposed forestry development and its subsequent activities should all be carefully planned and timed with information on the behaviour and breeding or migratory times of these priority species to prevent or minimise the impact on them.

Overall, negative impacts should always be avoided where possible, and by doing so, the proposed forestry development can proceed in a way that balances the economical, ecological and environmental objectives.

4.2.2 Mitigation

To mitigate the ecological impacts of forestry development, a comprehensive approach focusing on afforestation, placement, and management plans for the existing biodiversity is essential.

Afforestation should involve the careful selection of tree species that are native and well-adapted to local conditions, promoting resilience and adaptability in the ecosystem. This strategy will not only enhance local biodiversity but also contribute to broader environmental goals such as carbon sequestration and habitat connectivity. Informed decisions in species selection, taking into account the long-term ecological balance, will ensure sustainable forest development. Moreover strategic thinning of trees in overstocked areas is also crucial to enhance overall forest and ecosystem health, productivity and sustainability.

Mitigation efforts must also focus on the physical layout and construction activities within the forest. Establishing buffer zones of native trees and vegetation around water bodies will help filter pollutants and prevent soil erosion, thereby protecting the excellent aquatic ecosystems present on both proposed plots. Furthermore, the design and placement of roads, skid trails and timber landings should be carefully planned to minimise habitat fragmentation and ecological disruption. Utilising existing trails where feasible and positioning landings in less sensitive areas can significantly reduce ecological impacts.

The development should also include management plans for protected or priority species, ensuring their conservation amidst forestry activities such as Red Squirrels which were recorded in our survey on site. Although recent studies found that Red squirrels could cope with standard thinning operations without significant detriment to survival or breeding success (de Raad et al., 2021), management plans should still be in place to facilitate dispersal into adjacent forest in the case of complete felling of the forest (Kortland et al. 2022).

Additionally, the control of invasive species, such as Rhododendron, is crucial to prevent them from displacing native flora and altering the ecological dynamics of the area. As in the case of Rhododendron, they are known to negatively impact the health of native Silver Birch woodland present in Lochranza. Following invasive species removal, restoration efforts should focus on re-establishing native plant communities to recover the damaged biodiversity and improve ecosystem resilience.

By implementing these mitigation strategies, the forestry development can minimise its ecological footprint, support biodiversity conservation, and maintain the integrity of natural habitats. These actions will contribute to the sustainable management of forest resources while maximising the preservation of the ecological value of the landscape.

4.2.3 Compensation

Not all the negative impacts can be avoided and compensation measures are therefore essential to address the unavoidable losses and residual impacts on biodiversity despite the mitigation measures. BIodiversity offsets compensate for the ecological impacts of the development by establishing new habitats or enhancing existing ones at a nearby location to provide alternative habitats for the affected biodiversity offset the impacts. With careful planning, we can ensure these new habitats can support the same biodiversity and ecological functions as the ones lost. The compensation from biodiversity offsets can be easily quantified by using the same metric, for instance hectares of habitat of a particular quality, enabling the demonstration of “no net loss” and in some cases net gains (CIEEM, 2022).

Additionally, allocating a portion of the revenue generated from forestry operations towards conservation efforts presents an effective way to counterbalance the environmental footprint of the development. This financial contribution can support various initiatives, such as funding local conservation projects, sponsoring research on sustainable forest management, or investing in community-based environmental programs. By reinvesting in the ecosystem, forestry operations can help enhance and preserve biodiversity in other areas, potentially leading to broader environmental benefits beyond the immediate locality. Such financial commitments signify a responsible approach to forestry development, acknowledging the importance of maintaining biodiversity and ecosystem integrity while pursuing economic objectives.

4.2.4 Ecological enhancement

Ecological enhancements from forestry development in particular in the Northern Plot can have a multifaceted impact on local wildlife and habitats. The introduction of trees, particularly in areas currently dominated by less diverse vegetation, can lead to a shift in bird populations. While it might reduce the number of certain common species, it could enhance the diversity of specific bird families, promoting a more varied avian community. This change in habitat structure can create new ecological niches and enhance overall biodiversity.

Forestry in the Northern Plot offers a potential ecological benefit by alleviating the pressure of overgrazing on the existing Silver birch woodland in the Southern Plot. By providing alternative woodland habitats, forestry development can potentially divert deer populations away from these pressured areas, thereby alleviating one of the critical negative pressures on the existing Silver BIrch woodland.

Additionally, coniferous trees are typically planted for commercial forestry. Such an environment would provide a range of potential benefits to the Red Squirrel, a priority species recorded in the Northern Plot. The afforestation of forestry developments not only offer an abundant food supply through cone production but also facilitate the creation of habitat corridors, enhancing connectivity between isolated habitats. This is crucial for the movement and genetic diversity of squirrel populations.

Furthermore, implementing forestry on the mid and lower sections of the Northern Plot or the midsection of the Southern Plot could transform monocultural grasslands into more diverse habitats. This change would significantly improve the habitat quality for a wide range of wildlife, contributing to the overall ecological resilience of the region. By carefully selecting tree species and managing forest growth, forestry development can support and enhance existing woodlands, making them more resilient to environmental changes and pressures.

4.3 Limitation of selected ecological sampling methods

The ecological sampling methods employed in assessing the potential impacts of the proposed forestry development have certain limitations that must be acknowledged to properly interpret the findings.

4.3.1 Plants

Our assessment on plants in this Ecological Impact Assessment are disproportionately lacking compared to the importance they hold in the ecosystem health and diversity. We performed a Phase 1 habitat survey which primarily identified key and invasive species, omitting a comprehensive assessment of the entire plant community. Systematic sampling was limited to trees, as they were easier to identify compared to other plant species, leading to a potential underrepresentation of the total plant diversity in the area.

The team's lack of botanical expertise further limited the depth of the survey, suggesting that future assessments would benefit from more specialised knowledge and techniques, such as the use of quadrats alongside transect data. Additionally, challenging terrain in the Southern plot resulted in incomplete transect coverage, which may have led to an incomplete representation of tree species in that area. These factors combined imply that the plant diversity and distribution findings from our current survey may not fully reflect the actual ecological characteristics of the plots.

4.3.2 Birds

Our bird survey faced several limitations that could affect the accuracy of our results. The reliance on auditory identification posed a risk of underestimating bird numbers due to overlapping calls or difficulty in judging distances. Conversely, visual identification carried the risk of double counting, especially as our movement during transect walks might have driven birds forward, potentially leading to overestimation. However, these biases are generally accepted in bird sampling and might offset each other to some extent.

Additionally, the exclusion of flyover birds from counts could have led to underestimations of total avian abundance. Adverse weather conditions like wind and limited visibility in the Northern plot likely resulted in missed observations, and noise pollution near the distillery in the Southern plot may have further impacted bird detection. The challenging terrain in the Southern plot also hindered complete transect coverage, affecting the representation of avian species associated with certain tree species. These factors collectively suggest that while the survey provides valuable insights, the data should be interpreted with an understanding of these inherent limitations.

4.3.3 Mammals

4.3.3.1 Camera Traps

Our sole reliance on camera traps in sampling land mammals faced limitations that affected the comprehensiveness of our results as camera traps are not equally effective in sampling all mammal groups under different habitat conditions and does not guarantee the detection of all individuals. Dense vegetation often obscured smaller mammals, and could cause bias in the placements of camera traps. This could have contributed to low species richness recorded in the vegetation dense Southern Plot, where no small mammals and only Red Deer were recorded.

Two out of three camera traps in the Northern Plot also encountered issues on the very first night of sampling, where one was obstructed by a fallen branch, while another was knocked over to the ground, resulting in a limited field of view. Although data was still recorded by the knocked-over camera, its compromised positioning impacted the quality of the data. Additionally, ethical and licensing constraints prevented the use of trapping methods for small mammals, which would have provided a more comprehensive understanding of the small mammal community particularly in the Southern Plot to confirm their presence or absence. More diverse sampling methods should be used in future studies to ensure a more comprehensive assessment of the mammals in the proposed plot.

4.3.3.2 Audiomoths

Our use of Audiomoth for bat sampling faced certain limitations impacting the reliability and interpretability of the results. The data we obtained from the audiomoths were only a probability of detection and identification by the “batdetect2” tool in Python Anaconda, these probabilities only indicate the likelihood of presence and are not a guaranteed observation. The use of audiomoths also does not guarantee the detection of all individual species, leading to less conclusive presence and absence data.

Additionally, with only one audiomoth available, sampling events for different plots and habitats had to be conducted on separate nights. This introduced a variable of differing weather conditions on each recording night, potentially affecting both the bats' activity and the equipment's sensitivity. Consequently, this variation may impact the consistency and comparability of the data across different plots and habitats. These limitations highlight the need for cautious interpretation of the results and suggest that further studies with better resources and more robust sampling designs would be beneficial for a comprehensive understanding of bat populations in the proposed plots.

4.3.4 Terrestrial Invertebrates

Our terrestrial invertebrate sampling method faced several challenges that affect the comprehensiveness of our results. The difficulty in species identification in the field due to time and resources limitation meant most samples were only identified down to family level. The challenging terrain of the lower transect, characterised by dense bracken and streams, restricted our use of pitfall traps to only a portion of this area in both plots. Additionally, the setup of these traps was complicated by the difficult terrain, limiting our sampling range. Inclement weather, particularly persistent rain, frequently flooded the pitfall traps, rendering them ineffective and leading to their discontinuation under such conditions. A large portion of the Southern plot was also inaccessible for sweep-netting again due to the challenging terrain and inclement weather. Due to time and resource constraints, only pitfall traps and sweep-netting were used. Although they are very effective in collecting ground-dwelling invertebrates and invertebrates that live on plants, different sampling methods only target a certain population of the diverse taxa of terrestrial invertebrates. Technical issues meant the moth traps were not used, leading to a gap in our records for nocturnal invertebrates. Furthermore, the wooded environment of the Southern plot presented a different habitat type where methods such as branch beating could be more effective and should be considered in future surveys.

4.3.5 Aquatic Invertebrates

Our aquatic invertebrate sampling had several limitations that potentially impacted the comprehensiveness and accuracy of our results. Identifying larvae in the field proved particularly challenging, as we lacked specialised equipment and expertise, which constrained our ability to precisely classify these organisms. Additionally, there were variations in our sampling protocols across different sites due to differing habitat potentially led to imbalances in our sampling efforts, thereby affecting the standardisation and comparability of our results. Moreover, our identification of most species was limited to the order level, and had to be omitted from our water quality assessment as we were unable to attribute a Biological Monitoring Working Party (BMWP) score for them. This significantly restricted the utility and representativeness of our BMWP and ASPT scores for water quality assessment. This level of identification may not fully reflect the diversity in the sampled aquatic ecosystems and could limit the accuracy of our ecological assessments.

4.3.6 Excluded Taxa

Amphibians and reptiles were excluded from our ecological assessment primarily due to the challenges associated with their sampling despite being observed on site. It was out of season to sample amphibians and reptiles in September when the survey was conducted and the sampling of these taxa required specialised equipment which were not available at the time. Notably, there was an incidental sighting of a common toad (*Bufo bufo*) in the marshes in the Southern Plot (see Table. 1), which is one of the priority species identified by our desk-based survey.

Similarly, fish were also excluded from our assessment due to the complexities of fish sampling, which requires distinct protocols and often specific permits, presenting additional logistical challenges. Therefore, while recognizing their ecological significance, we exclude these groups based on practical considerations and the limitations of our current assessment capabilities and would recommend future assessment on these taxa for a more comprehensive understanding of the aquatic ecosystems in the proposed plots.

4.4 Recommandations

Considering the ecological data and the constraints of the Site of Special Scientific Interest (SSSI) status of the Southern Plot, the recommendation for the location of commercial forestry development leans towards the Northern Plot. This decision is based on several factors:

Diversity and Abundance:

While both plots exhibit comparable diversity and abundance across most taxa, there are significant differences in mammal, bird and tree populations.

The Northern Plot supports a wider range of mammals, including red squirrel, a priority species, while red deer was the only mammal recorded by our camera traps in the Southern Plot (see Fig. 17). However, the lack of any Rodentia or other common small mammals captured in our camera traps in the Southern Plot suggest the monospecies sample could also simply be a result of obscuration from the dense vegetation in the Southern Plot as described earlier in the limitation of our selected sampling methods.

Although The Northern Plot's higher bird abundance, most of the differences came from common species like the Corvids (see Fig. 16) with the presence of invasive Kestrel (see Fig. 16). The invasive plant Rhododendron sampled only in the Northern Plot further suggests it is already subject to anthropogenic influence, which might be less impactful when considering additional development.

Priority Species:

The presence of the Red Squirrel, a priority species, in the Northern Plot further justifies the development of a typical coniferous forestry. Such an environment would not only offer an abundant food supply through cone production but also facilitate the creation of habitat corridors, enhancing connectivity between isolated habitats. This is crucial for the movement and genetic diversity of squirrel populations.

Invasive Species:

The presence of Rhododendron, an invasive species, in the Northern Plot suggests it is already subject to anthropogenic influence and further supports the suitability of this plot for forestry development. Forestry management measures might help control the spread of such species, whereas the Southern Plot should be managed for conservation to protect its SSSI status and the unique species like Silver Birch that contribute to its ecological value.

The Common Kestrel, another invasive species only recorded in the Northern Plot, might prefer the more open baseline habitat in the Northern Plot. Forestry development along with management plan there could potentially reduce the population of this invasive species.

Habitat Preference:

Red deer prefer woodland habitats, hence the current presence in the Southern Plot and absence in the Northern Plot where tree abundance is significantly lower (see Fig. 7). The overgrazing from deer is a known negative pressure on the SIlver Birch woodland, a key feature of the Arran Northern Mountains SSSI also in the Southern Plot. Forestry development in the Northern Plot could alleviate some of the pressure on the Silver Birch woodland in the Southern Plot by potentially redirecting deer populations.

The Northern Plot seems to be favoured by least concerned species like the Corvids and invasive species like the Common Kestrel that prefer open habitats. Afforestation could perhaps change the composition of the bird community and create habitat suitable for more sensitive native birds that prefer wooded areas.

SSSI Status and Conservation Pressures:

The Southern Plot's designation as an SSSI means that any development would be heavily regulated and require additional consent, which could complicate and delay forestry activities. Furthermore, the plot is already facing pressures from overgrazing and invasive species, suggesting that conservation efforts should be prioritised here rather than development.

Ecological Impact:

The potential ecological impact of commercial forestry is likely to be less in the Northern Plot, where the presence of non-native and invasive species indicates a degree of habitat resilience or prior disturbance. On the other hand, the Southern Plot's SSSI status is indicative of high conservation value that would be best maintained and protected from further development.

In summary, the Northern Plot is recommended for commercial forestry development due to its potential benefits to the prioritised Red squirrels, higher bird abundance of least concerned species, the presence of invasive species that could be managed through forestry, and the lack of SSSI status, which provides more flexibility in management decisions. This recommendation aligns with the need to balance economic development with ecological conservation, preserving the sensitive Southern Plot for its ecological significance and unique biodiversity

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6. Appendices

Appendix 1: NBN atlas search results for the desk-based survey

Plot	Species	Status
Northern	*Cuculus canorus*	Invasive
Northern	*Falco tinnunculus*	Invasive
Northern	*Linaria cannabina*	Invasive
Northern	*Passer domesticus*	Invasive
Northern	*Saxicola rubetra*	Invasive
Northern	*Sciurus vulgaris*	Invasive
Northern	*Turdus philomelos*	Invasive
Northern	*Hyacinthoides non-scripta*	RSPB priority species
Northern	*Sciurus vulgaris*	RSPB priority species
Northern	*Cuculus canorus*	Biodiversity Action Plan UK list of priority species
Northern	*Passer domesticus*	Biodiversity Action Plan UK list of priority species
Northern	*Sciurus vulgaris*	Biodiversity Action Plan UK list of priority species
Southern	*Acer pseudoplatanus*	Invasive
Southern	*Cygnus olor*	Invasive
Southern	*Neovison vison*	Invasive
Southern	*Rhododendron ponticum*	Invasive
Southern	*Rubus spectabilis*	Invasive
Southern	*Anguilla anguilla*	RSPB priority species
Southern	*Boloria selene*	RSPB priority species
Southern	*Bufo bufo*	RSPB priority species
Southern	*Hyacinthoides non-scripta*	RSPB priority species
Southern	*Sciurus vulgaris*	RSPB priority species
Southern	*Anguilla anguilla*	Biodiversity Action Plan UK list of priority species
Southern	*Boloria selene*	Biodiversity Action Plan UK list of priority species
Southern	*Bufo bufo*	Biodiversity Action Plan UK list of priority species
Southern	*Coenonympha pamphilus*	Biodiversity Action Plan UK list of priority species
Southern	*Cuculus canorus*	Biodiversity Action Plan UK list of priority species
Southern	*Numenius arquata*	Biodiversity Action Plan UK list of priority species
Southern	*Passer domesticus*	Biodiversity Action Plan UK list of priority species
Southern	*Salmo trutta*	Biodiversity Action Plan UK list of priority species
Southern	*Sciurus vulgaris*	Biodiversity Action Plan UK list of priority species
Southern	*Sorbus arranensis*	Biodiversity Action Plan UK list of priority species

Appendix 2: Biological Monitoring Working Party (BMWP) Average Score per Taxon (ASPT) Scoring System. (Hansel et al, 2006)

Taxonomic Class	Taxonomic Families	Score
Ephemeroptera	Ephemeridae	10
	Heptagoniidae	10
	Leptophlebiidae	10
	Pothamanthidae	10
	Siphonurridae	10
Plecoptera	Capniidae	10
	Chloroperlidae	10
	Leuctridae	10
	Perlidae	10
	Taeniopteterygidae	10
Hemiptera	Aphelochereididae	10
Trichoptera	Beraecidae	10
	Brachycentridae	10
	Goeridae	10
	Lepidostomatidae	10
	Leptoceridae	10
	Mollanidae	10
	Odontoceridae	10
	Phyrgancineidae	10
	Sericostomatidae	10
Ephemeroptera	Caenidae	7
Plecoptera	Nemouridae	7
Trichoptera	Rhyacophilidae	7
	Polycentropodidae	7
	Limnepphilidae	7
Mollusca	Neritidae	6
	Viviparidae	6
	Ancylidae	6
	Unionidae	6
Trichoptera	Hydroptilidae	6
Crustacea	Corophiidae	6
	Gammaridae	6
	Paleamonidae	6
Polychaeta	Nereidae	6
	Nephthyidae	6
Odonata	Plaqthycnemididae	6
	Coenagriidae	6
Hemiptera	Mesovelidae	5
	Hydrometridae	5
	Gerridae	5
	Nepidae	5
	Naucoridae	5
	Notonectidae	5
	Pletidae	5
Coleoptera	Corixidae	5
	Haliplitidae	5
	Hygrobiidae	5
	Dytiscidae	5
	Gyrinidae	5
	Hydrophilidae	5
	Helobidae	5
	Dryopidae	5
	Eliminthidae	5
	Chyssomelidae	5
	Curcuionidae	5
Phyrgancineidae	Hydropsychidae	5
Diptera	Tipulidae	5
	Simullidae	5
Planaria	Planariidae	5
	Dendrocoelidae	5
Ephemeroptera	Baeitilidae	4
Megaloptera	Sialidae	4
Hirudinea	Piscicolidae	4
Mollusca	Valvatidae	3
	Hygrobiidae	3
	Lymnaeitidae	3
	Physidae	3
	Planorbidae	3
	Sphaeriidae	3
Hirudinea	Erpobdellidae	3
	Glossiphonidae	3
	Hirudidae	3
Crustacea	Asellidae	3
Diptera		
Oligochaeta		
Others	Alderfly	4
	Shrimps	6
	Hoglice	3
	Blackfly	5
	Cranefly	5
	Madgse	2
	Worms	1

BMWP = sum of score of organism found
ASPT = divided by the number of group found

5 – 5	excellent
4 – 4.5	good
3 – 3.5	moderate
2 – 2.5	poor
1 – 1.5	very poor