Project Design Document (PDD) based on the IUCN Green List Standard for Carbon (GLS+)

Pilot in the canton of Appenzell Ausserrhoden, Switzerland

Figure 1: Forest reserve of Schwägalp - Bruggerwald in Switzerland

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Introduction

The goal of this pilot study is to test the assumptions made in the newly developed IUCN Green List Standard for Carbon (GLS+). GLS+ allows to identify carbon sinks in Protected and Conserved Areas (PCA), calculate the amount of CO2 sequestered through management activities and opens up a way to bring these CO2 Certificates onto market. GLS+ is an independent Standard but 60% of the indicators are identical with the ones used in the existing IUCN Green List Standard (GLS), a global program of certification aiming to achieve and promote effective, equitable, and successful protected and conserved areas. GLS+ is adding the possibility to create high quality carbon credits and new funds generated can be used to finance the GLS Application process or to improve management techniques in PCA. The Pilot is run on real data generated through a biodiversity intervention in the year 2021 to favor the locally endangered Western Capercaillie (*Tetrao urogallus*) and is only testing the potential for CO2 certificates without creating them.

Pilot Region

The forest reserve of Schwägalp - Bruggerwald is located in the communities of Urnäsch and Hundwil, canton of Appenzell Ausserrhoden, Switzerland. It is located on the prealpine mountainous region at the altitude of 1200m a.s.l. and measures at 230 ha of forest. The forest is composed of 95% of Norway spruce (*Picea Abies (L.) H. Karst.*) and is at the maximum of its growth potential. This forest reserve has been categorized as a specific forest reserve by the Federal Office of the Environment of Switzerland (FOEN), which implies the protection and preservation of endangered species and environments (OFEV, 2020). To achieve its purpose, the FOEN allows a number of management practices, delegated to local forest practitioners. In the Schwägalp - Bruggerwald, the forester Forstbetrieb am Säntis has been mandated to manage the forest for the conservation of the Western Capercaillie. Although categorized as a “least concern” species for their global population by IUCN (IUCN Redlist, 2016), their population is a priority concern for Swiss bird specialists (Vogelwarte.ch, s. d.). The Swiss federal authority (FOEN) suggests different management practices to conserve this species, the main objective being the creation of an open forest and adequate environment for the reproduction and life cycle of this large bird (OFEFP, 2001). The forest is not very productive (mean DBH: 26m) and the area has not been logged for more than 100 years. Based on national law, the forester must retain trees of old age and favor structural diversity in the stand. The stand must not be altered in its ecological sense (using chemicals, drainage of swamps)

and promote deadwood by leaving the dead or logged trees on the forest floor. Last but not least, the forester must refrain from silvicultural activities during the mating and the raising of the young capercaillies (i.e. February to mid-July).
The Project is analyzing an old cut from 2021 and is estimating the eligibility and expected CO2 equivalents for a new cut.

Requirements

A.1. Eligibility criteria

The following requirements represent the 60% of Indicators lent from the IUCN Green List Standard (GLS).

1.1.1 Documented governance structure

The forest reserve of Schwägalp - Bruggerwald is managed by the forest company Forstbetrieb am Säntis, who is mandated by the forest reserve owners. The forest owners are a variety of entities, mainly private landowners, the community of Urnäsch and the canton of Appenzell Ausserrhoden. In collaboration with the forester, the Porini Foundation is responsible for the redaction of the PDD and piloting of the carbon project.

1.1.2. Opportunities to participate in decision making for the stakeholders

All stakeholders with legal rights on the forest reserve are integrated in the management of the area. Stakeholders can make use of their rights on the parcel at any time of the project. Additionally, the project makes sure the public opinion on the project is respected and honored. Thus, the acceleration of the protection of the Capercaillie (symbol of the nature of the region) can only benefit the public opinion of the project activities (OFEFP, 2002).

1.1.3 Legitimate rights of indigenous people

Not relevant in Switzerland as there are no indigenous people.

1.1.5 Advancement in gender equity in relation to management of the site

Switzerland is highly ranked internationally in terms of gender equality (World Economic Forum, 2021). Furthermore, decisions are taken according to the stakeholders and not as a community.

1.1.6 Acceptance of governance structure

The governance structure is accepted by the aforementioned stakeholders as many public and private entities are involved in the conservation of the Western Capercaillie.

1.3.1 Monitoring used as a tool for effective management practices

Additionally to the monitoring of the capercaillie by biologists mandated by the cantonal office of space and forest and community of Urnäsch, the carbon sequestration and visualization of the forest reserve increases the precision of the data available on the parcel. The results will allow the forester to optimize the conservation activities and adapt the management plan of the forest reserve.

1.3.2 Planning and decision-making recognizes relevant conditions, issues and goals at national and regional scales

The conservation of the Capercaillie is of national and cantonal importance (OFEFP, 2002; Vogelwarte.ch, s. d.). The Swiss government is actively promoting the mating environment in forest reserves throughout the country. The project supports the conservation process of the species.

1.3.3. Multiple knowledge source for management

The project draws from multiple knowledge sources ranging from peer reviewed papers, official documents published by the cantonal and federal office of environment and local knowledge from the forester. The project believes in a combination of the sources to create a relevant and satisfactory result.

1.3.4. Planning around future projections

Although the climate change effects are generally of larger proportions in mountainous regions, we conclude the natural shift in species supported by the creation of openings and increasing biodiversity is the most effective and efficient transition mechanism (Knoke et al., 2008; Lüpke, 2004; Lebourgeois et al., 2013, Jactel et al., 2009). The plantation of specific tree species is therefore not applied. On socio-economic aspects, we expect little change in the governance and laws in forest areas in Switzerland.

2.1.1. Governance structure

We identified multiple stakeholders for the project area.

Canton of Appenzell Ausserrhoden: part owner of the forest area and mandates the forester for conservation activities.

Community of Urnaesch and Hundwil: part owner of the forest area and mandates the forester for conservation activities.

Private landowners: part owner of the forest area and mandates the forester for conservation activities.

Forstbetrieb am Säntis (the mandated forester): Forest management and logging company represented by Alexander Plaschy. They operate as a steward for the forest reserve.

2.1.2. Protected and Conserved Area (PCA) Categories

The PCA is classified as IUCN Category IV, a habitat or species management area with a focus on an identifiable species requiring continuous protection. The primary objective of this forest reserve is to conserve Capercaillie, a nationally important species.

2.1.3. Management plan:

The management plan of the parcel is orientated towards the protection of the capercaillie. Logging activities are only allowed to create openings in the dense forest to facilitate the mobility of this large bird and allow it to mate and feed the chicks. Capercaillies have very high demands on their habitat, according to OFEFP (2001), the male capercaillie needs diverse species of trees (European Beech, Pine and Silver fir), an open environment (50%-70% cover), structural diversity with escape corridors, undisturbed forests, blueberry floors and with many laying deadwood. The female capercaillie has the same preferences as the males except while raising the chicks where ground vegetation of high herbs are ideal. Pure spruce forests without vegetation on the forest floor, dark areas and artificial or large areas of regeneration are not suited for the species. Considering that the forest is mainly composed of spruce, it is important for the forester to create openings and allow other species to slowly colonize the area. Furthermore, creating openings can allow other tall grass species to colonize the area. Overall, we estimate that this management practice will increase the general biodiversity on top of the conservation of the endangered bird. Increased number of tree species is also linked to greater resilience to climate change and will likely allow the forest to remain a forest in the next decades.

As a means to protect the area and keep the carbon in the forest, the forester makes a carpet of branches on the forest paths. This practice typically prevents excessive compression of the forest soil by heavy machinery (OFEV, 2016).

2.1.4. Natural values and ecosystem services

The forest reserve has been established for the conservation of the Capercaillie. The wood extracted from the forest reserve must be used in long lasting structures such as buildings. The price of wood being high and the precaution in its harvesting increases the emotional value of the resource and will not be used for single use items. The portion of wood traditionally transformed into firewood (i.e. branches) will be left in the forest in order to increase the soil quality and carbon sequestration. Finally, the capercaillie holds a cultural value in the minds of the local population as it is featured in many community flags across Switzerland (OFEFP, 2002). The protection and conservation of the species in Switzerland is therefore important.

3.1.4 Appropriately trained staff and effective management team

The project area is managed by the forester Forstbetrieb am Säntis. This company employs only certified foresters (Forstbetrieb am Säntis, 2022). Furthermore, the management activities are regulated by the cantonal office of space and forests of Appenzell Ausserrhoden.

3.5.3 Laws and regulations

The project respects the federal and cantonal laws and regulations in terms of the forest reserves and the issuance of carbon credits.

- SR 921.0 Federal Act of 4 October 1991 on Forest (Forest Act, ForA),
- 921.01 Ordinance on forest of 30 November 1992 (Forest Ordinance, ForO),
- SR 814.81 Ordinance of 18 May 2005 on the Reduction of Risks relating to the Use of Certain Particularly Dangerous Substances, Preparations and Articles (Chemical Risk Reduction Ordinance, ORRChem) (Swiss Confederation, 2005)
- 922.0 Loi fédérale sur la chasse et la protection des mammifères et oiseaux sauvages (Loi sur la chasse, LChP) (Swiss Confederation, 1986)

According to LChP, logging activities in the protected area are not allowed, but can be accepted for biodiversity measures such as to create a suitable environment for the protected species.

For tourist activities, the forest is restricted to hiking on the designated paths only. This rule of conduct is suggested to the visitors by posters at the entrance of the reserve.

Figure 2: Information Panel at the entrance of the Eidg. Jagdbanngebiet am Säntis

3.6.2. Use and access

The access to the PCA is restricted to short pathways and activities such as barbecues and picnics are only possible at designated fireplaces (Figure 2).

GLS+ Carbon requirements:

A carbon project in the forest reserve Schwägalp-Bruggerwald is considered a nature based solution as its primary goal is to protect and conserve the Capercaillie. Through opening up the dense forest, the forester is able to create a suitable ecosystem for the bird, hence providing biodiversity benefits and to extract wood used in long-lasting structures. Additional requirements are that the area has not been logged for the purpose of generating carbon credits for the last 10 years and has not seen a conversion from the original forest land.

A.2 Additionality requirements

This project supports the conservation of the Western Capercaillie in the forest reserve Schwägalp-Bruggerwald. Although the conservation area is supported by the canton of Appenzell Ausserrhoden, the additional funding provided through the carbon credits issued from the GLS+ can increase the managed area and accelerate the protection of this nationally endangered bird. The carbon sink created by the wood products used in long lasting structures and the rapid carbon capture from the growth of the young trees are being monitored and quantified in tCO2e.

The project follows the steps defined in the latest (as of July 2022) “Tool for the demonstration and assessment of additionality” version 7.0 from UNFCCC.

Step 1: Identification of alternatives to the project activity consistent with mandatory laws and regulations

Step 1a: Define alternatives to the project activity:

- Business-as-usual: The forester is mandated by the forest owners to apply the adequate management practices on the forest parcels to conserve the Capercaillie. As part of his plan, the forest is managed at the rate of 5 ha every 5 years. The conservation of the whole area would therefore take up to 200 years, depending on the public funding.
- Conversion from reserve to private or public production forest: The forest reserves is converted to a managed forest and sold to a public or private entity. The forest would be then managed as other neighboring forests.
- Conversion from specific to natural forest reserve: The special forest reserve is converted to a natural forest reserve. The new status of the forest entitles no intervention to the natural environment and processes in the reserve (OFEV, 2020).

Step 1b: Consistency with mandatory laws and regulations:

- Business-as-usual: This scenario is in line with the laws, contracts and management plan in place for the concerned area. **We estimate that this scenario is the most likely and will be used as the baseline scenario.**
- Conversion reserve to private or public production forest: The conversion would break the contract between the Swiss Government and the landowner(s) (private or/and public). The Western Capercaillie is critically endangered in Switzerland and is protected. Common logging activities of the area would therefore hinder the habitat of the bird. It would therefore break the Swiss law on hunting and the protection of wild mammals and birds (Swiss Confederation, 1986).

- Conversion from specific to natural forest reserve: By definition, the natural forest reserve is without intervention in the project area (OFEV, 2020). This conversion would not allow opening up dense forest necessary for the survival of the Capercaillie and is therefore unlikely to happen. has to be promoted in order for the species to thrive. The lack of management would also reduce the effects previously obtained.

Step 2: Investment analysis

As payment for the management of the area, the canton of Appenzell Ausserrhoden distributes funding to the forester each 5 years based on the management plan and the issuance of carbon credits would allow the forester to increase the area managed to better protect the species.

Step 2a: Determine the appropriate analysis method

The cost of extracting wood is higher than the obtained financial benefits of the sale, we therefore conduct a simple cost analysis.

Step 2b: Simple cost analysis

The management contract between the forester and the canton of Appenzell Ausserrhoden for the period 2020 to 2024 allows us to make our **cost analysis on real data**. For the year 2021, a parcel of 2.5 ha was treated. The total costs of the intervention was 68’929 CHF leaving a deficit of 33’644 CHF (see annex 1 for details). The reason for this deficit lies in the difficulty to harvest the area and even if the forester can ask compensation from the canton of Appenzell Ausserrhoden, the deficit will limit the transformation of the forest for the Capercaillie. Additional funding from Carbon credits would therefore allow the forester to increase the managed area for Capercaillie.

Assuming the costs for the management are constant for the next period, we can calculate the additional hectares that are possible to be managed by the forester. The current value of carbon credits are estimated at 25 USD, approx. 25 CHF (Ernst & Young Australia, 2022). We calculate the benefits with this conservative and fixed rate, but we emphasize that the selling price for high quality carbon credits generated in Switzerland might already be higher and is expected to increase to US$80-$150 per tonne by 2035 (Ernst & Young Australia, 2022). In order to manage additional surfaces for Capercaillie, the carbon credits generated would need to compensate for the deficit.

Step 3: Barrier analysis

According to the “Tool for the demonstration and assessment of additionality” version 7.0 from the UNFCCC, the barrier analysis is not necessary for this project to fulfill the requirements of additionality,

Step 4: Common practice analysis

Sub-step 4b: Analyze other activities similar to the proposed project activity:

This project is looking at the generation of carbon credits in a forest reserve. The generation of carbon credits in other legacy registries are predominantly done on managed forest where the project area is differently managed.

A.3 Double-Counting

The project is not registered under any carbon registry but the GLS+

A.4 Permanence

We used the METT-4 standard to assess the threats and risks of the forest area for the next 30 years. The results show that 79% are of low threat and 86% of medium and low threat severity (Figure 3). The assessment shows a particularly low (>75%) threat level which is typical for a PCA and according to the GLS+ standard classification, no credit reserve is necessary.

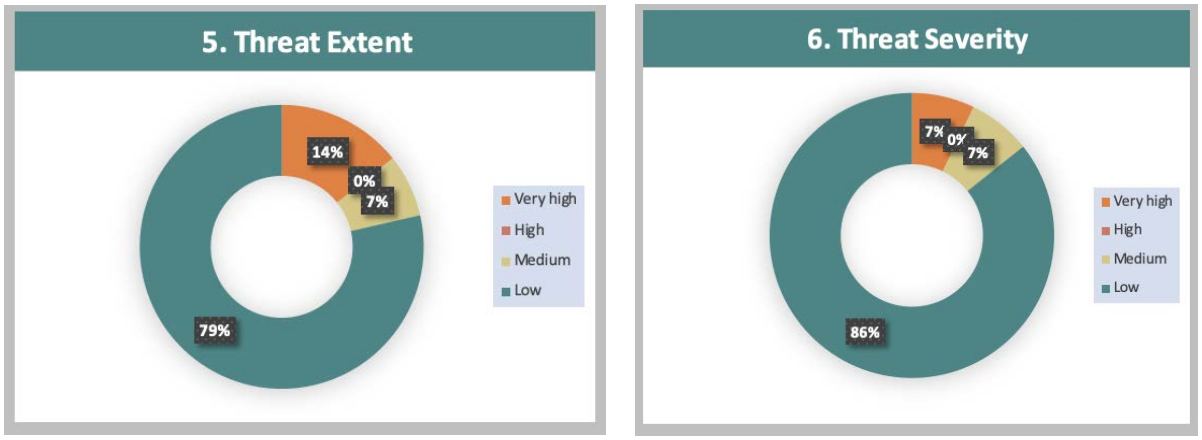

Figure 3: Threat extent and severity, extracted from the METT-4 assessment

Threats in the mountainous region of Switzerland are drought, extreme temperatures, invasive species, avalanches and storms and can severely damage the forest. To counter these threats, the forester is opening the forest favoring light demanding species (Knoke et al., 2008; Lüpke, 2004; Lebourgeois et al., 2013, Jactel et al., 2009). Furthermore, increasing the structural diversity improves the resistance of the forest to storms and other disturbances (Pluess et al., 2016). Federal forest laws and ordinance favor the resilience of forests in regard to stress and climate change induced threats (SR 921.0 - Federal Act of 4 October 1991 on

Forest (Forest Act, ForA), 1991; SR 921.01 - Ordinance of 30 November 1992 on Forest (Forest Ordinance, ForO), 1992).

B. Scenarios

B.2 Business as Usual (BAU) scenario

The project has identified 3 different scenarios possible for the forest reserve (see also 1a) :

1. The forest reserve continues to follow the management plan defined by the office of environment of the canton of Appenzell Ausserrhoden. The forest is slowly converted to an ecosystem viable for the capercaillie. In this scenario, 5 ha are managed every 5 year and it is expected to take up to 200 years to have the whole forest reserve managed. Additional Interventions would improve the habitat for capercaillie and satisfy the wish of the cantonal office of Appenzell Ausserrhoden to increase logging in the Prealpine region of the canton. This forest has not been managed for more than 100 years and the carbon sequestration potential is assumed to be in equilibrium. Opening up the forest for Capercaillie will therefore create new carbon sinks.

2. The forest reserve is converted to a managed forest. In this scenario, the forest reserve is managed by the forester as a logging area. Here, the forester applies a similar strategy to comparable areas in the vicinity and by the same forester. In Switzerland, clear cutting a forest is forbidden (Swiss Confederation, 1991), however, intensive logging is possible. We estimate that intensive logging practices would not be applied in a Prealpine forest as the costs of the exploitation are high mainly due to the difficulty of access.
   This scenario is unlikely since the management of the project area for the capercaillie is designed for long periods of time.

3. The forest is converted to a strict forest reserve removing the possibility for biodiversity interventions. This process is relatively long and costly, but the forest could be converted to a strict reserve without human intervention. In this scenario, the forester would only intervene for security reasons along roads or public places to reduce risks caused by the forest.
   This conversion is unlikely since the forest was created to protect this nationally important bird species and allowing interventions to maintain the area suitable for this species being scarce, is aligned with the conservation objectives of Switzerland.

Based on the assessment of the different scenarios, we conclude that the first scenario is most likely to happen.

B.3 Project scenario

The project scenario revolves around the sequestration of carbon in wood products.

Opening the forest canopy by logging actively improves the quality of the ecosystem for the capercaillie and acts indirectly in favor of the shift in tree species due to climate change by favoring the light demanding and drought resistant species over natural rejuvenation (Jactel et al., 2017; Knoke et al., 2008). Compared to other wood markets, the cost of logging in Swiss mountainous regions is high and relatively low in volume (Achim Schafer, 2021). The wood is often sold to local customers and used for construction purposes. Using this wood for construction will remove carbon from the forest and allow the forest to bind additional carbon while regrowing, thus creating a carbon sink.

B.1 to B3 Calculation of the baseline and scenarios

Datasets used for calculation:

swissALTI3D: This model from Swisstopo is a precise digital elevation model (30 cm accuracy) which describes the surface of Switzerland without vegetation and development. (Swisstopo, n.d.). We used the 2019-2020 model. The use of this simplification may create errors, these are described in the limitations section of this criterion.

swissSURFACE3D: This surface model represents all natural and man-made objects of the surface of Switzerland in the form of a classified point cloud (Swisstopo, s. d.). These high-accuracy and high spatial density data are collected by airborne LiDAR and provide precision up to 10 cm vertically and 20 cm horizontally. Here we used the 2017-2018 model. The use of this simplification may create errors, these are described in the limitations section of this criterion.

Tree species data: The forester responsible for the area provided all necessary data on the species composition of the forest reserve out of the management plan. The forester estimated a majority of Norway spruce in the area (95%). Upon further inspection in the forest we could confirm the approximation of the forester (Figure 4).

Figure 4: Spruce dominance in the forest reserve Schwägalp - Bruggerwald

Programs used for calculation:

QGIS Version 3.22.9 LTR: We use the Tree density calculator (v. 1.5.7.) plugin to calculate the treetops and their associated height. The Tree Density Calculator is a QGIS plugin and command line interface package designed to calculate tree densities based on brightness images, using the local maximum in a sliding window (Ann Crabbé et al., 2020).

Rstudio 2022.02.3: Rstudio allows R version 4.2.0 (2022-04-22) to run. Used for statistical analysis (R Core Team, 2022).

BWinPro 7: A growth simulation model used to support silviculture and timber activities in Germany (Land Brandenburg, 2022) (Figure 5). This model was used instead of similar models from Canada as the tree species, management practices and climate are more similar to ones found in Switzerland.

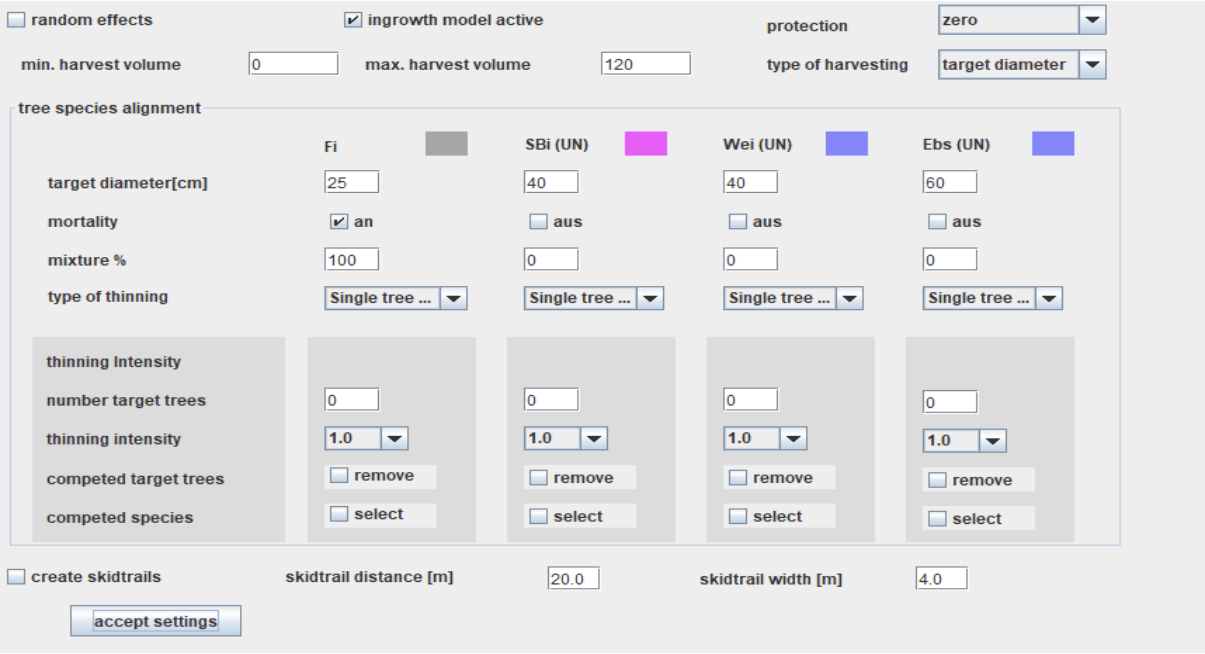

Figure 5: BWinPro 7: A growth simulation model

Table 1: Measured sinks and sources

Sink	Inclusion	Explanation
Aboveground ligneous biomass	Yes	Trees and their crowns represent most of the carbon sequestered in the forest
Aboveground non ligneous biomass	No	Difficult to measure. Maybe in the future
Deadwood	No	Not precise. Only approximation is possible.
Belowground ligneous biomass	No	Root systems are not extracted and therefore remain constant
Soil carbon	No	Not precise and cost-efficient models. Possible improvement in the future.

Sources	Inclusion	Explanation
Firewood	Yes	Is the part of the harvested wood which can not be used for construction

Methodology:

Identification of the trees and their characteristics at baseline

1. Create polygon of the parcel

2. Create the Canopy Height Model by subtracting the swissALTI3D (Digital terrain model) to the swissSurface3D model. By subtracting the two datasets, the resulting elevation model provides information on the vegetation of the forest area. Function on Raster Calculator.
3. Using the plugin Tree Density Calculator, identify all the trees from treetops. The density of the tree is set at default values of 5 meters minimum between each treetop.
4. Select by location (intersect) all the treetops with the parcel of the forest reserve, and extract the selected attributes in a new point dataset.
5. In the last dataset, extrapolate the DBH (in cm) from tree height using the allometric equation mentioned in the paper by Tatarinov et al. (2005).
6. Select by attributes all the trees with a DBH > 12cm. We set the threshold of a tree at 12 cm because Swiss NFI defines a tree at this DBH. The saplings can then be discarded.
7. Extract the count of trees per ha by dividing the total number of trees by the total ha of the forest reserve.

GIS Results

GIS model

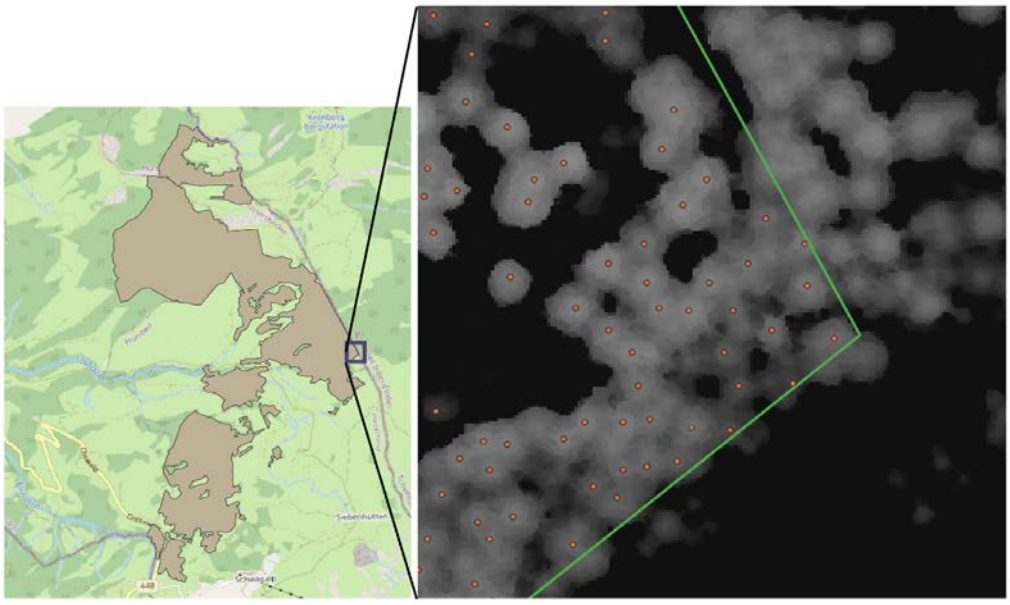

Figure 6: Map of the project area (left) and Canopy height model with identified tree tops (right).

We identified a total of 26’229 trees over 228.6 ha, with an average of 114.74 trees per ha. The trees have a mean height of 26.03 m and mean DBH of 32.12 cm (Annex 3).

Table 2: Characteristics of the trees in the area. Extracted from QGIS and calculated on R

	Mean	Median	Max	Sd
Height (m)	26.03	27	54	5.9
DBH (cm)	32.12	33.23	64.35	6.78

BwinPro 7 model inputs:

Although the model can be parameterized for any size of parcels, we argue that it is not necessary to input the total area (228.6 ha) since the forest parcels are quite uniform and have a similar DBH distribution. We therefore ran the model on a 1ha parcel and extrapolated the results to the total area.

Table 3: Input data in BWinPro 7. The input data will define the treatments and management practices.

Input data	Overstory	Young trees
Initial state	Create Trees	Create tree
Species	511:Fi (Norway spruce)	511:Fi (Norway spruce)
Number of trees	115 trees (114.74 trees need to be rounded for the model)	115 trees (114.74 trees need to be rounded for the model) (see Assumptions and uncertainties)
Random effect	No	No
Ingrowth model active	No	No
Target DBH	30 cm	-
Treatment	First year	Regrowth period
Protection	None	None

Result from BWinPro 7 model

Baseline

Using the model with these parameters based on the previous GIS analysis, we estimate the extractable biomass volume for each hectare at 108.9 m3/ha. The model creates a distribution of trees on a parcel and calculates the total biomass volume (Figure 7).

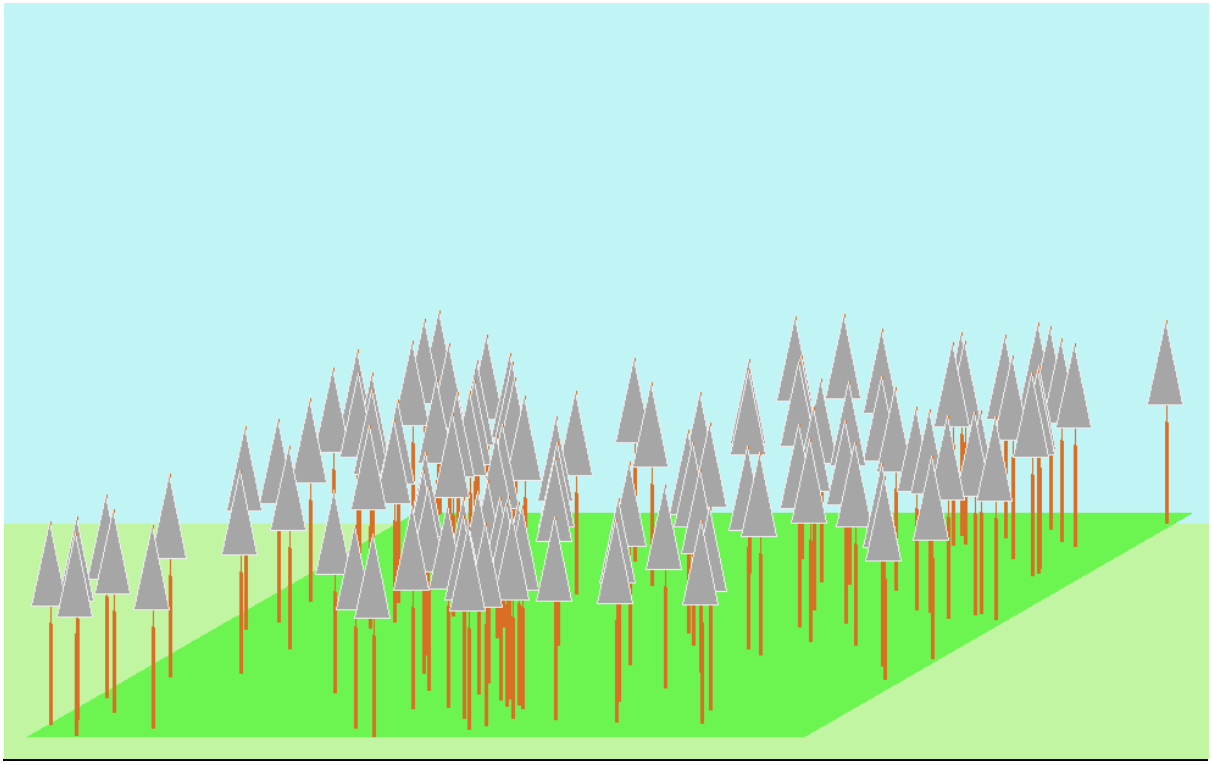

Figure 7: Visualization of the distribution of tree in BWinPro.

Estimation of the sequestration of carbon

In the model, we set the treatment of the forest on clear cut. Although forbidden by Swiss law (Swiss Confederation, 1991), we want to calculate the full potential of sequestration in logged areas and then will adapt this amount to the actual logging strategy focused on the extraction of single trees with a BDH of 25 cm and above. In the actual model, forest regeneration is set to 50 years only but we estimate that regeneration in Prealpine forests in Switzerland must take 80 to 120 years to regrow. Fast growth rates in the model are however secondary as only the harvested volume of wood at each period is subject to carbon crediting. Furthermore, remote forests in high slopes are less likely to be harvested before trees attain maturity.

Firewood / Total wood extracted

In Switzerland, it is estimated that 60% of the wood is actually transformed into hardwood (Mehr et al., 2018). The rest of the volume is either discarded or simply burned. The sequestration of carbon into wood is therefore lower than the amount extracted. In numbers:
108.9 (m3/ha) * 60% = 65.34 m3/ha

Conversion of total hardwood products into tC of dry mass

In Switzerland, it is estimated that spruce wood has a density of 390 kg per m3 (Fischer & Traub, 2019). Conventionally, the relationship between dry matter and tC is set at 0.45 for temperate forest species (IPCC, 2006). Therefore:
65.34 (m3/ha) * 390 (kg) / 1000 * 0.45 = 11.46 tC/ha

Conversion to tCO2e

The conversion from tC to tCO2e is of 3.67. For example, 1 tC becomes 3.67 tCO2e (US EPA, 2015). Therefore:
Total sequestered in tCO2e per ha= 11.46 * 3.67 = 42.08 tCO2e /ha.

Total potential of sequestration of CO2 in the forest reserve

By multiplying the total sequestered in tCO2e per ha with the total area of the forest reserve (ha) we obtain a maximum sequestration of :
42.08 (tC/ha) * 228.6 (ha) = 9619.49 tCO2e

Simple cost analysis

The 9619.49 tCO2 carbon tons sequestered in the total area of the forest reserve would add up to a total of 240'000 Swiss francs (240'487 CHF). The amount of 42.08 (tC/ha) per ha managed for capercaillie would generate 1'052 CHF of additional funding. This amount does not allow to cover the deficit involved for the harvesting of the parcel but can be an additional incentive. The most important factor to manage a larger area for Capercaillie is to reduce the harvesting costs, especially the transport costs which in our real world example have been very high due to the use of helicopter services to transport the wood out of the forest (see Annex 1).

Assumptions and uncertainties

In order to estimate the total volume of credits to be issued, a certain number of assumptions and simplifications were necessary.
First, the Altitude model swissAlti3D and the surface model swissSurface3D were of 2019/2020 and 2017/2018, respectively. The gap in years between the baseline (2022) and the model can create uncertainties in the result. We estimate however that the differences are negligible since the parcels have not been exploited significantly and that the dataset serves to estimate the average number of trees per ha, the average height and DBH. In areas where logging has occurred in the period between the baseline and the sampling of the remote sensing data, the trees should be relatively small and are not accounted for as trees must be above 12 cm DBH to be considered in our analysis.
Second, the simplification regarding the formula for root systems and height/DBH ratio can be a source of errors in the extrapolated data. This simplification is however necessary as all the trees cannot be measured directly for DBH. Furthermore, the measurement of carbon stored in root systems is extremely work intensive and cannot be performed here.
Third, the growth of the forest has been measured using a model that is calibrated for plains in Germany and offers only an estimation of the total potential of growth.

Also the amount of young trees (approximately 12 cm DBH) has been set at 115 trees/ha. The number of young trees should naturally be higher but with the existing model, it is not possible to take into account these numbers as well as competition in and between species.
Last, the use of a model developed for German plains may induce errors as the net increment of tree species at different altitudes is not taken into consideration and the regeneration pace of young trees is overestimated.

C. Monitoring plan and verification

C.1 Monitoring plan

The monitoring plan consists of following the steps taken in section B. At each monitoring period, the forester must deliver the amount logged in the area and the parcel size during the last period. From this information, the exact amount of credits to be issued can be calculated. The baseline of the project is also calculated in order to prove the management practices carried out in the reserve. The report by the cantonal office on the management of the forest is also added to the verification document if available for the period.

C.2 Improvement on the calculation methodology:

The methodology is bound to be adapted at each time of monitoring. We expect several data sources and software updates. For instance, the quality of the remote sensing data is expected to increase. Furthermore, the possibility to assess the variation in soil carbon can be expected after the issuance of the first credits. Also, the versions of the QGIS software and the tree density calculator plugins will likely be updated.

Conclusion and learnings

60% of the requirements for the Green List Standard (GLS) are also necessary for the Carbon Standard (GLS+). Starting the GLS+ process for carbon may therefore lead the path to continue with the GLS certification and vice versa.
The sequestered amount of 42.08 (tC/ha) and the value represented of 1’052 CHF does not cover the deficit/ ha necessary in our Swiss Pilot project, but in other parts of the world, with lower management cost, this additional funding stream could allow additional biodiversity measures or the extension of the managed area.

Sources:

Abegg, Brändli, Cioldi, Fischer, Herold, Meile, Rösler, Speich, & Traub. (2020). *Inventaire forestier national suisse—Tableau no 890768* [Data set]. Birmensdorf, Institut fédéral de recherches WSL. https://doi.org/10.21258/1494794

Achim Schafer. (2021). *2021 Market Statement for Switzerland Developments in Forest Product Markets* (BAFU-061.2-03-08-6/9/1/4). UNECE.

Bošeľa, M., Konôpka, B., Šebeň, V., Vladovič, J., & Tobin, B. (2014). Modelling height to diameter ratio—An opportunity to increase Norway spruce stand stability in the Western Carpathians. *Lesnícky časopis - Forestry Journal*, *60*, 71-79. https://doi.org/10.2478/forj-2014-0007

Crabbé, A. H., Cahy, T., Somers, B., Verbeke, L. P., & Van Collie, F. (2020). *Tree Density Calculator Software (Version 1.5.7)* (1.5.7). https://bitbucket.org/kul-reseco/localmaxfilter

Dudley, N. (2008). *Guidelines for applying protected area management categories*. IUCN. https://doi.org/10.2305/IUCN.CH.2008.PAPS.2.en

Ernst & Young Australia. (2022). *Essential, expensive and evolving : The outlook for carbon credits and offsets* (N° NZ20224-001353). EY Net Zero Centre.

Fischer, C., & Traub, B. (2019). *Swiss National Forest Inventory – Methods and Models of the Fourth Assessment*. Springer Nature.

Forstbetrieb am Säntis. (2022). *Forstbetrieb am Säntis : Mit Herz und Verstand im Wald aktiv*. Forstbetrieb am Säntis. https://forstbetriebamsaentis.ch/ueber-uns

IPCC. (2006). *Capter 12 HARVESTED WOOD PRODUCTS- IPCC Guidelines for National Greenhouse Gas Inventories*.

IUCN Redlist. (2016). *Western Capercaillie*. IUCN Red List of Threatened Species. https://www.iucnredlist.org/species/22679487/85942729#assessment-information

Jactel, H., Bauhus, J., Boberg, J., Bonal, D., Castagneyrol, B., Gardiner, B., Olabarria, J., Koricheva, J., Meurisse, N., & Brockerhoff, E. (2017). Tree Diversity Drives Forest

Stand Resistance to Natural Disturbances. *Current Forestry Reports*, *3*, 223-243. https://doi.org/10.1007/s40725-017-0064-1

Knoke, T., Ammer, C., Stimm, B., & Mosandl, R. (2008). Admixing broadleaved to coniferous tree species : A review on yield, ecological stability and economics. *European Journal of Forest Research*, *127*(2), 89-101. https://doi.org/10.1007/s10342-007-0186-2

Land Brandenburg. (2022). *LFE Waldwachstumsimulator BWinPro | Landesbetrieb Forst Brandenburg*. https://forst.brandenburg.de/lfb/de/ueber-uns/landeskompetenzzentrum-lfe/lfe-waldwachstumsimulator-bwinpro/

Lebourgeois, F., N, G., Pinto, P., & Mérian, P. (2013). Mixed stands reduce Abies alba tree-ring sensitivity to summer drought in the Vosges mountains, western Europe. *Forest Ecology and Management*, *303*, 61-71. https://doi.org/10.1016/j.foreco.2013.04.003

Lüpke, B. (2004). Risikominderung durch Mischwälder und naturnaher Waldbau : Ein Spannungsfeld. *Forstarchiv*, *75*, 43-50.

Mehr, J., Vadenbo, C., Steubing, B., & Hellweg, S. (2018). Environmentally optimal wood use in Switzerland—Investigating the relevance of material cascades. *Resources, Conservation and Recycling*, *131*, 181-191. https://doi.org/10.1016/j.resconrec.2017.12.026

OFEFP. (2001). *Grand Tétras et gestion de la forêt*. https://www.bafu.admin.ch/bafu/fr/home/themen/thema-biodiversitaet/biodiversitaet--publikationen/publikationen-biodiversitaet/auerhuhn-und-waldbewirtschaftung.html

OFEFP. (2002). *Des forêts diversifiées et tranquilles pour sauver le grand tétras*. https://www.admin.ch/gov/fr/accueil/documentation/communiques.msg-id-7313.html

OFEV, O. fédéral de l'environnement. (2016). *La protection des sols en forêt contre les atteintes physiques*. https://www.bafu.admin.ch/bafu/fr/home/themen/thema-wald-

und-holz/wald-und-holz--publikationen/publikationen-wald---holz/physikalischer-bodenschutz-im-wald.html

OFEV, O. fédéral de l'environnement. (2020). *Réserves forestières*. https://www.bafu.admin.ch/bafu/fr/home/themen/thema-biodiversitaet/biodiversitaet--fachinformationen/massnahmen-zur-erhaltung-und-foerderung-der-biodiversitaet/oekologische-infrastruktur/waldreservate.html

Pluess, A. R., Augustin, S., & Brang, P. (2016). *Forêts et changements climatiques. Éléments pour des stratégies d'adaptation—Publikationen—WSL*. https://www.wsl.ch/de/publikationen/forets-et-changements-climatiques-elements-pour-des-strategies-dadaptation.html

R Core Team. (2022). *R: A language and environment for statistical computing* (4.2.1). R Foundation for Statistical Computing. https://www.R-project.org/

Swiss Confederation. (1986). *RS 922.0—Loi fédérale du 20 juin 1986 sur la chasse et la protection des mammifères et oiseaux sauvages (Loi sur la chasse, LChP)*. https://www.fedlex.admin.ch/eli/cc/1988/506_506_506/fr

Swiss Confederation. (1991). *RS 921.0—Loi fédérale du 4 octobre 1991 sur les forêts (Loi sur les forêts, LFo)*. https://www.fedlex.admin.ch/eli/cc/1992/2521_2521_2521/fr

Swiss Confederation, & EFBS. (2015). *Plantes exotiques envahissantes : Détection précoce – réaction immédiate*. Swiss Confederation.

Swiss Federal Council. (2019). *Incendies de forêts. Mesures efficaces et modernes de lutte et de prévention*. Swiss Confederation.

Swisstopo. (s. d.-a). *SwissALTI3D*. Federal Office of Topography Swisstopo. Consulté 5 août 2022, à l'adresse https://www.swisstopo.admin.ch/en/geodata/height/alti3d.html

Swisstopo. (s. d.-b). *SwissSURFACE3D*. Federal Office of Topography Swisstopo. Consulté 5 août 2022, à l'adresse https://www.swisstopo.admin.ch/en/geodata/height/surface3d.html

Tatarinov, F., Bochkarev, Y., Oltchev, A., Nadezhdina, N., & Cermak, J. (2005). Effect of contrasting water supply on the diameter growth of Norway spruce and aspen in mixed stands : A case study from the southern Russian taiga. *Annals of Forest Science*, *62*(8), 807-816. https://doi.org/10.1051/forest:2005086

US EPA, O. (2015, août 28). *Greenhouse Gas Equivalencies Calculator* [Data and Tools]. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Vogelwarte.ch. (s. d.). *Grand Tétras | Station ornithologique suisse*. vogelwarte.ch. Consulté 12 août 2022, à l'adresse https://www.vogelwarte.ch/fr/oiseaux/les-oiseaux-de-suisse/grand-tetras

World Economic Forum. (2021). *Global Gender Gap Report 2021*. https://www.weforum.org/reports/global-gender-gap-report-2021/digest/

Annex:

Annex 1: Invoice of management activity in the forest area

The logging activity has been carried for approximately 2.5 ha of forest reserve.

FORSTBETRIEB
Urnäsch | Hundwil | Stein AM SÄNTIS.

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Amt für Raum und Wald
Herr Beat Fritsche
Kasernenstrasse 17A
9102 Herisau

Urnäsch den 12.11.2021

Abrechnung für Holzschlag Nusshalde 2021

Arbeitsausführung: September 2021

Holzerlös

Bezeichnung	Menge			Preis		Preis
Bauholz	360.36	m^3	à SFr.	94.84	SFr.	34'178.15
Hackholz	55.35	m^3	à SFr.	20.00	SFr.	1'107.00
Total Holzerlös	***415.71***		***SFr.***	***84.88***	***SFr.***	***35'285.15***

Auszahlung Waldbesitzer

Bezeichnung	Menge			Preis		Preis
Personal						
Rundholz BC	334.52	pau.	à SFr.	3.00	SFr.	1'003.56
Personal					**SFr.**	**1'003.56**

Aufwand

Bezeichnung	Menge			Preis		Preis
Personal						
Forstbetrieb am Säntis	1.00	pau.	à SFr.	23'660.00	SFr.	23'660.00
Personal					**SFr.**	**23'660.00**
Maschinen / Fahrzeuge						
Engeli und Marti	1.00	pau.	à SFr.	2'400.00	SFr.	2'400.00
Heli Linth	1.00	pau.	à SFr.	42'869.00	SFr.	42'869.00
Maschinen / Fahrzeuge					**SFr.**	**45'269.00**
Aufwand Forstbetrieb Urnäsch	**165.8103**				**SFr.**	**68'929.00**
Mwst.	*7.7%*	*auf*	*SFr.*	*68'929.00*	*SFr.*	*5'307.53*
					SFr.	**74'236.53**
Holzerlös abzüglich Auszahlung WB					**SFr.**	**34'281.59**
Unser Guthaben					**SFr.**	**39'954.94**

DER FÖRSTER:

Besten Dank für den geschätzten Auftrag
Frundliche Grüsse
A.Plaschy

Recht herzlichen Dank für das entgegengebrachte Vertrauen in unseren Forstbetrieb.

WERKHOF FURT, 9107 URNÄSCH TEL. 071 / 364 15 76 FAX 071 / 364 15 79

A.3 Double counting statement

Project Name: Carbon project of the forest reserve Schwägalp-Bruggerwald

Name Surname: Kenta Perret

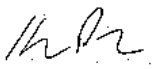
Company and Address :
Porini Foundation
Rue Pierre-Aeby 1
1700 Fribourg
Switzerland

This contract document serves as a confirmation that the project area is not under any other carbon offset program.

The breach of this contract results in the breach of trust between the protected and conserved area and the carbon credit issuer, as well as the stop of the issuance of the GLS+ carbon credits, until resolution and/or correction of the fault. Carbon credits from the reserve of the previous period will also not be issued, if existing.

Place and date
Bern, 23.08.22

Signature



Annex 3: Sample of the tree counts in the area with Tree Height (m) (RasterVal), Height/Diameter ratio(dimensionless) (HDRatio) and Diameter at Breast Height (cm) (DBH), visualized on R.

	RasterVal	HDRatio	DBH
1	31	81.928	37.838
2	31	81.928	37.838
3	27	81.246	33.232
4	30	81.774	36.686
5	27	81.246	33.232
6	31	81.928	37.838
7	29	81.610	35.535
8	30	81.774	36.686
9	29	81.610	35.535
10	31	81.928	37.838
11	29	81.610	35.535
12	27	81.246	33.232
13	30	81.774	36.686