SUPERB
Upscaling Forest Restoration

Vindelaven-Juhttátahkka Unesco Biosphere reserve, Sweden

Restoration Workplan

Planned delivery date (as in DoA): M13
Due date of deliverable: December 2022
Workpackage: WP7

Demo leader: Åsa Granberg; Johan Svensson
[asa.granberg@lansstyrelsen.se; johan.svensson@slu.se]
Version: 1.0
Dissemination level: Public

Grant Agreement number: 101036849
SUPERB — H2020-LC-GD-2020 / H2020-LC-GD-2020-3
Project Acronym: SUPERB
Systemic solutions for upscaling of urgent ecosystem restoration for forest related biodiversity and ecosystem services
Duration of the project: December 1st, 2021 - November 30, 2025

VERSION HISTORY

Version	Date	Author /Reviewers	Partner	Description
0.1	30.05.2022	Authors: Johan Svensson, Bengt-Gunnar Jonsson	SLU	First draft description
0.2	17.07.2022	Reviewer: Silke Jacobs	WR	Review first draft description
0.3	21.10.2022	Authors: Åsa Granberg, Johan Svensson, Bengt-Gunnar Jonsson	V-J, SLU	More or less complete version of the workplan for review.
0.4	28.11.2022	Reviewer: Klaus Kremer, WP6	University of Freiburg	Internal review
0.9	20.12.2022	Authors: Åsa Granberg, Johan Svensson, Bengt-Gunnar Jonsson	V-J, SLU	Final version for submission
1.0	21.12.2022	Editor: Silke Jacobs	WR	Final edits

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ACKNOWLEDGEMENT

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement no. 101036849.

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1 Restoration goals

1.1 General demo description

The Swedish demo area consists of the entire area of Vindelälven-Juhttátahkka UNESCO Biosphere Reserve (Gardeström et al. 2018). The Biosphere Reserve covers a 1.3 million ha river catchment from the alpine areas of the Scandinavian Mountain Range at the border to Norway to the coast of the Gulf of Bothnia. Along this extensive gradient, the current forest and vegetation types are distributed based on climate, altitude, site richness and soil moisture conditions, natural variation in parent material etc., but also on the type, degree and duration of land use. The main land covers include (Figure 1.1)

- forests (52%, of which ca 89% are considered as productive and thus of interest for wood biomass production),
- open alpine environments (18%),
- wetlands (12%),
- subalpine mountain birch treeline forest (8%)
- waterbodies (7%).

Agricultural lands and urban areas are sparsely distributed and situated mainly along the cost and in valleys along rivers and streams.

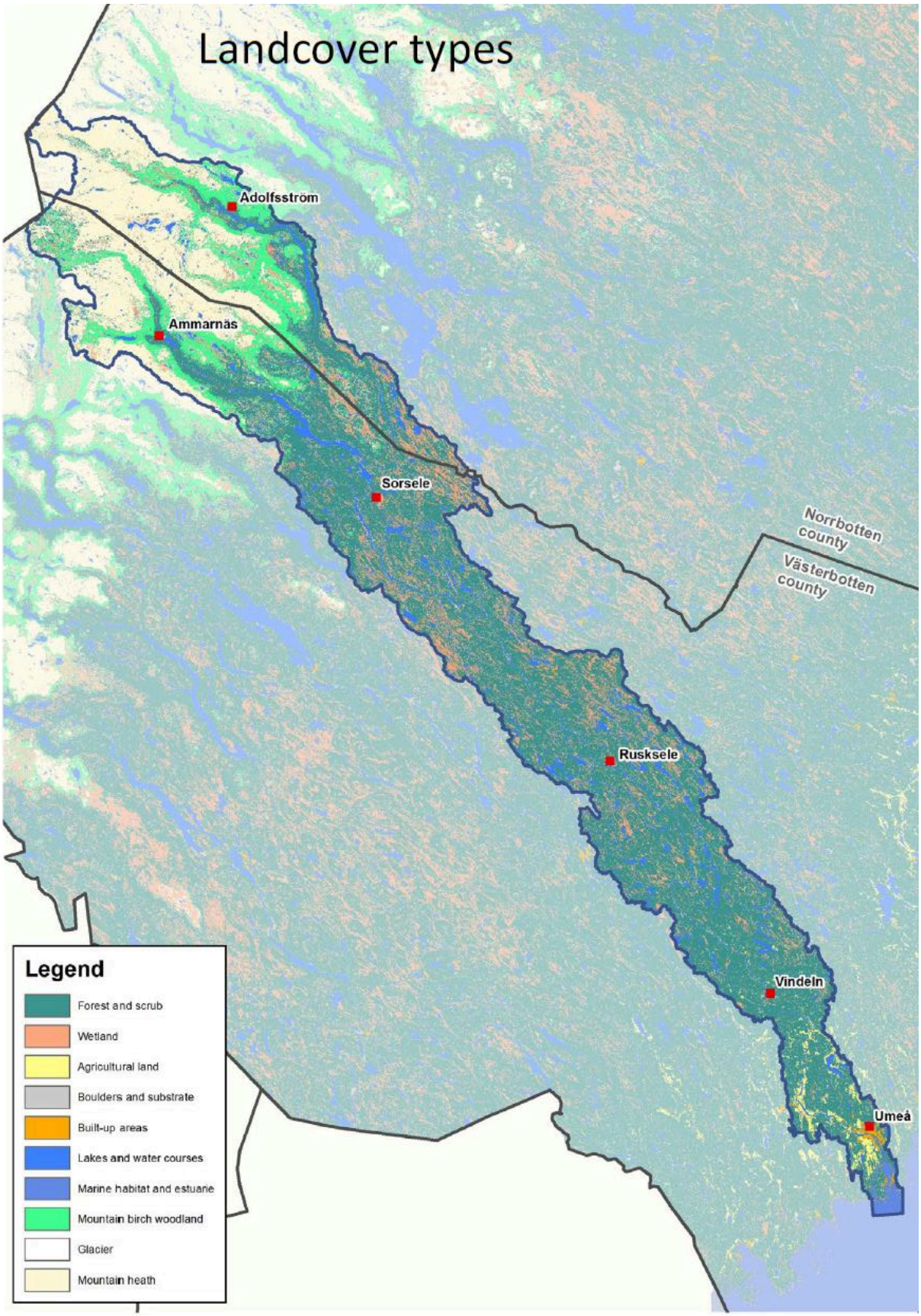

Figure 1.1 Map showing the distribution of different landcover types within the Vindelälven-Juhttátahkka Biosphere Reserve.

The forests within the Biosphere Reserve are naturally dominated by native conifers, mainly Scots pine (*Pinus sylvestris*) in areas with dryer and wetter conditions and Norway spruce (*Picea abies*) in areas with more mesic conditions. Deciduous trees, mainly birches (*Betula pendula* and *Betula pubescens*) but also Aspen (*Populus tremula*), Goat willow and other tree forming Salix species (*Salix caprea et al.*), Rowan (*Sorbus aucuparia*) and Bird cherries (*Prunus padus*) naturally occur within the coniferous forests in different proportions, depending on abiotic conditions but also on natural disturbances and past management. Deciduous dominated forest almost only occurs naturally in forest margins and as a phase in natural succession after major disturbances, such as fire, landslides or erosion. Deciduous dominated forest also occurs naturally in river deltas or along the coast where new land is constantly emerging due to material deposit and postglacial land uplift. Permanent deciduous stands only occur naturally in the treeline forest where the mountain birch (*Betula pubescens ssp. czerepanovii*) dominates and in wet and regularly flooded areas where Gray Alder (A*lnus incana*) often are the dominating tree species. Fire is the natural, large-scale disturbance that is driving forest dynamics in the area, especially in areas with dryer growth conditions and thus pine dominated, while small-scale gap dynamics are of greater importance in areas that naturally are more spruce-dominated.

Special characteristics

Postglacial land uplift – At present, the land in the coastal areas of the Biosphere reserve is rising approximately 9 mm/yr. Due to the flat topography in the coastal areas the amount of new land emerging from the sea is significant and the habitat (mainly type 9030) that is created is unique and characteristic for the area. However, the effect of the land uplift is decreasing as the sea level rises due to the climate change, meaning that this unique habitat type is threatened.

Unregulated river – The river Vindelälven is one of few unregulated, large rivers ("National rivers") in Sweden and thus the riverbank environments are exposed to major seasonal and stochastic variations in water flow. This creates diverse environments that are beneficial for the flora and Vindelälven has one of Sweden's most species-rich riverbanks. However, both the main river and its tributaries were heavily transformed during the timber floating period, mainly by clearing the streams from boulders and rocks. During the last decade, the structure of many of the tributaries have been restored.

Allemansrätten – Most of the outdoor life in Sweden is based on the *Right to public access,* stating that, as long as one does not disturb and destroy, the public have the right to hike, camp (for up to two nights), make a small fire, pick berries and mushrooms etc. in nature, independently of who owns the land. However, hunting, fishing and cutting trees and branches are not included.

Within the Biosphere Reserve approximately 380 000 ha are protected according to the EU Habitats Directive. The following Natura 2000 forest types are present within these protected areas, with 9010 Taiga being the most common:

- 9010 Taiga, with all subtypes represented
  - natural old spruce forests
  - natural old pine forests
  - natural old mixed forests
  - natural old deciduous forests
  - recently burnt areas
  - younger forests naturally developed after fire
- 9050 Fennoscandian herb-rich forests with *Picea abies*
- 9030 Natural forests of primary succession stages of landupheavel coast
- 9040 Nordic subalpine/subarctic forests with *Betula pubescens* ssp. *Czerepa-novii*
- 9070 Fennoscandian wooded pastures
- 9080 Fennoscandian deciduous swamp woods

- 91D0 Bog woodland
- 91E0 Alluvial forests with Alnus glutinosa and Fraxinus excelsior
- 7310 Aapamires (in which also forested mire-islands might be included)

Within the Biosphere Reserve the following EEA forest types (Technical report No 9/2006) are present:

- 6.1 Boreal forest,
  - 6.1.1 Spruce-dominated
  - 6.1.2 Pine-dominated
- 6.3.2 Alpine coniferous forest, subtype Subalpine and mountainous spruce and mountainous mixed spruce-Silver fir -forest
- 6.11 Mire and swamp forests,
  - 6.11.1 Conifer dominated or mixed mire forests but also
  - 6.11.2 Alder swamp forest and
  - 6.11.3 Birch swamp forest
- 6.12 Floodplain forest
  - 6.12.1 Riparian forest
  - 6.12.2 Fluvial forest
- 6.13 Non-riverine alder, birch or aspen forest
  - 6.13.1 Alder forest (in primary succession stages of landupheaval coast)
  - 6.13.3 Mountain birch forest
  - 6.13.4 Other birch forest
- 6.14 Plantations and self-sown exotic forest

1.1.1 Human impact

Historically, the forests within the Biosphere Reserve have been used extensively by the indigenuous Sámi people; for reindeer grazing, firewood, material for constructs such as housing and fencing, etc. (Norstedt et al. 2014). In the early 1700, other groups of people started to use the land (Axelsson & Östlund 2001), mainly for small-scale agriculture along the river valleys, including utilisation of the nearby forests for grazing, firewood and timber for housing. From mid-1800, commercial harvest of timber became more and more important in the area, both for the mining and the timber industry. For the first hundred years of commercial forestry, felling was mainly done manually with axes, saws, and later with motorised chain saws, and only the largest trees were felled, leaving younger and smaller trees to regenerate the forest. Collecting and transportation of the timber were done with horses and the timber were floated along the water streams, to sawmills down streams and on the coast. In mid-1900, mechanisation took off in forestry and from 1960's clearcutting has been the dominating way of harvesting trees in the Biosphere Reserve.

Today, most of the forest land in the coastal and inland area of the Biosphere Reserve are the result from artificial, monocultural planting with selected provenances after clear cutting in combination with soil drainage and scarification (Angelstam et al. 2020). The silvicultural scheme normally includes pre-commercial thinning, two commercial thinnings and understorey cleaning before clear cutting, all steps with systematic selection of the most commercially viable coniferous trees.

The farming practice in the demo area has developed in a similar way. Before mechanisation and the use of artificial fertilizers, the farms in the demo area were small, collecting straw winter fodder to their animals from natural grassy and open areas such as mires and floodplains, and often let their animals graze in the nearby forests. This fostered high biodiversity pastures and meadows intermixed in the forest lands. Today the agricultural farms

need to be larger and more efficient to be able to carry themselves economically. As a result, most small, unfertilized pastures and meadows within the forested landscape have been abandoned and are today in different stages of succession to forest.

Due to the widespread systematic clear-cutting forestry, the remaining patches of natural and semi-natural forests are highly fragmented (Figure 1.2), especially in the coastal and inland areas of the Biosphere Reserve (Svensson et al. 2019). In these areas the patches of natural and semi-natural forests are mainly found in less productive stands, with less fertile, too wet or too dry soil, or on higher altitudes that have been hard to reach with the commonly used machinery.

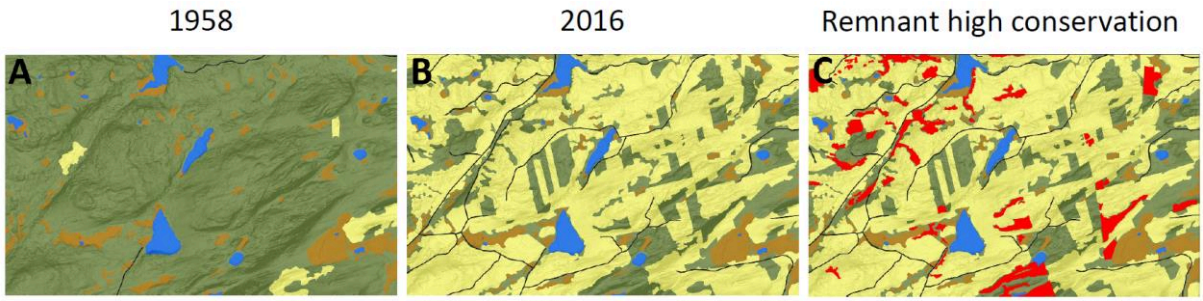

Figure 1.2 Map showing the difference in amount of natural and semi-natural forests (green) between 1958 and 2016 in a typical forested landscape in the inland of Västerbotten county (here exemplified by a 3000-ha landscape outside Bjurholm). Green - natural and semi-natural forests, yellow – areas that have been clear-cut, brown – wetland, open areas and villages, red – remnant areas of high conservation value. Svensson, J. et.al. In press.

However, larger areas of semi-natural forests and intact forest landscapes can still be found in the northwest mountain region. Overall, the mountain foothills “Scandinavian mountains green belt” (Svensson et al. 2020) provide unique intact forest characteristics and high ecological and cultural values. Thus, because of the imbalanced localisation of high conservation value forests, a vast majority of protected area are situated in the northwest. These forests may serve as core areas for biodiversity and act as dispersal sources to forests east of the mountain range, including newly restored forests where many typical forest species might be lacking.

Sámi culture and reindeer (*Rangifer tarandus*) herding

The indigenous Sámi culture and the reindeer husbandry sector is of core interest and value within northern Sweden and the Biosphere reserve Vindelälven-Juhttátahkka, demonstrated by the name *Juhttátahkka,* which is a Sámi dialect word for migration route understood as a route on the river at frozen conditions. The reindeer are central in the Sámi culture and the Sámi culture as such, performed and expressed by any Sámi person, are not only part of the identity of the Sámi people, but also a unique selling point for the northern part of Sweden.

The Sámi people have exclusive rights to reindeer husbandry, although most Sámi persons do not own reindeers. The reindeer herding is organised through communities known as samebyar (Reindeer herding community, RHC). A reindeer herding community is an economic and administrative unit entitled to manage the reindeer husbandry within a delineated geographical area. The RHC often incorporates several companies working in the reindeer husbandry sector. In Sweden there are 51 RHC's with the collective right to use approximately half of the Swedish territory for reindeer grazing, irrespectively of land ownership. Within the Biosphere reserve seven if the RHC's are represented: Ran, Gran, Svaipa, Maskaure, Malå, Ubmeje tjeälddie och Semisjaur-Njarg.

Reindeer husbandry has a long tradition but today the herders use modern technology to herd and guard the animals. However, an important characteristic for the reindeer husbandry in Sweden, both traditionally and today, is that it is transhumance and the reindeers roam freely in the search for areas to graze and rest in, and the herders follows the animals, more or less actively herding. Most RHC's are mountain communities, and their reindeers dwell in the mountain areas during summer and in the inland or by the coast during winter. Some RHC's are forest communities, keeping their reindeers within the forest all year around, although in different areas, depending on season. During spring and autumn, the reindeers are migrating between summer- and winterland. During winter the reindeers mainly eat lichen (e.g., ground living *Cladonia* sps. and tree living *Bryoria* sps.). In the summer the reindeers eat grass, herbs and leaves.

Today, each reindeer herding community are entitled to a certain number of reindeers, although the actual number may be further constrained by factors such as the amount of suitable grazing areas and limitations for natural migration from mountain to coast and back annually.

Up until the 19th century there were wild reindeers in Sweden, but today all are considered as semi-domesticated and thus not allowed for hunting. The grazing from reindeers has an important impact on the vegetation, especially in the mountains above the treeline, and grazing by reindeers has been proposed to be one factor that can counteract the effects of climate change in the mountain regions and maintain the open mountain landscape character.

1.1.2 Demography, land ownership structure, and business sectors

The human population of < 0.5 persons / km^2 is low and highly concentrated to the coastal area with the city of Umeå as the county capital. The area includes multiple types of forest ownerships including public, state and private forest companies, municipalities, national authorities, the church, and non-industrial private ownership of which some are associated with a private forest association. Generally, non-industrial private owners dominate in the

coastal area, whereas public state ownership is dominant in the northwest mountain area, and both private and state companies are found the inland area.

The Biosphere Reserve area is representative for northern Sweden with an economy dependent on forestry and other natural resources, as well as energy production. However, as in northern Sweden and Fennoscandia in general, the recreation and tourism sectors are becoming increasingly more important whereas the forest industry sector is decreasing in terms of local and regional economic importance.

1.1.3 Expected effects of climate change in the area

Table 1.1 Expected effects of climate change in the area.

Primary climatic effects	Secondary climatic effects
– Rise of temperature, mainly during winter and along the coast – Increased precipitation, mostly notable during autumn-winter-spring Increasing sea levels	– Increased probability of heat waves – Prolonged growing season – Increased probability of drought during summer – Periods of cloudburst/downfall and generally heavy rainfall are becoming more common – Runoff is increasing and the flow-pattern in rivers and streams is changing – Snow conditions are changing; shorter yearly snow period and increasing probability of periods with temperatures above 0°C during winter, leading to ice crusts on the snow and on the ground. – Ice conditions are changing; shorter ice-season both on the sea, lakes, rivers and streams, with more unsecure ice – Less effects of land rise – Extreme weather events are becoming more common – Increased risks for reduced ground stability and unstable soil conditions

In the area, the climatic zones are shifting several kilometres northwards every year (Lindström et al. 2013). Similarly, the climatic zones are shifting upwards to higher elevations leading to an upwards movement of the treeline and a gradual reduction of alpine habitats. Because of this, typical mountain habitats and species are considered the most vulnerable to the ongoing climate change. Also other, typical “northern” species are likely to decrease in populations, although in general, species diversity is likely to increase in the region because of establishment of both native, more southern species, but also potentially invasive species including north American Lodgepole pine (*Pinus contorta*), that are actively planted at large scale within forestry but also regenerate naturally and invade managed forests as well as protected forests. Other typical habitats for the region that are likely to decrease are habitats connected to land-uplift, such as natural, primary successional forests along the coast, and species associated to these habitats.

The reindeer husbandry sector is already experiencing effects of the ongoing climate change, especially connected to changing conditions during winter. Among these, the increased risk for warmer periods during winter are one of the most problematic. It leads to more frequent thawing events and even rainfall in the middle of the winter, which in turn leads to ice crust on the snow and often an ice cover on the ground. This makes it difficult for the reindeers to find and reach the ground lichens and may lead to starvation if the reindeers are not fed artificially. Other climatic effects that affect reindeer herding are the changing ice conditions with shorter and less stable ice layers, since many of the traditionally used migration routes are partly

situated on rivers and lakes, as well as increased productivity in the forests, resulting in denser forests that are less suitable for lichens.

The forestry sector is likely to be affected both positively and negatively by the changing climate. Prolonged growing season and potentially increased wood biomass production might be positive, while increased risk for forest fires, drought stress and frost damage, potentially more wind felling by storms and a higher risk for snow-breaks impose potential negative effects. The changing climate might also increase the risk for outbreaks and damage from insects and fungal pests as well as grazing from moose and other ungulate species. For other forest-based ecosystem services, recreational activities and businesses that are dependent on snow will be affected as the snow period decreases due to climate change. Also, fishing and wildlife hunting and businesses based on these activities are likely to be affected, as some species of fish and huntable wildlife might increase while other might decrease.

1.1.4 Present forest restoration knowledge and experience within the region

As a contrast to the decreasing areas of natural and semi-natural forests in the landscape, there has been an increase of retention effort in Swedish forest management during the last decades, to promote biodiversity and maintain ecosystem functions. The driving forces for this have been the Swedish Forestry Act that was implemented 1994 and are demanding a certain retention effort, as well as the adoption of FSC and PEFC certifications that puts the retention demands even a bit higher. The ecological effect of the often-used retention approaches in Sweden has been evaluated, showing that these are not enough to maintain pre-harvest species composition, but survival of forest species is still larger than on conventional clearcuts (Gustavsson et al 2020). The most recent evaluation of the national environmental goal “Sustainable forestry” (Swedish Forest Agency 2022) shows an overall negative development.

In addition to this “basic level” of retention effort that today are taken in almost all managed forests, some of the largest forest companies in Sweden have started to define certain “eco-landscapes” in which they manage the forests with higher nature conservation ambitions and with more concern of recreational values and outdoor life than in the conventionally managed forest outside the landscapes (see e.g. Bergman & Gustavsson 2020). Several of these eco-landscapes are situated within or in the vicinity of the Biosphere Reserve Vindelälven-Juhttátahkka, e.g., *Ecopark Skatan*, owned by forest company Sveaskog and *Tjäderberget Diversity Park* owned by forest company SCA. The eco-landscapes might be used to test and explore different restoration measures, both in stands set aside from production and thus with pure biodiversity goals, but also to test alternative management regimes to increase biodiversity in stands with productivity goals. Examples of restoration measures taken or planned in the eco-landscapes within the Biosphere Reserve include prescribed burning, veternization of trees, felling/killing of conifer trees to increase proportion and growth of deciduous trees, fencing to reduce grazing on naturally regenerated Aspen and other deciduous trees, re-wetting by filling ditches, planting of deciduous trees (*Betula pendula* and *Alnus incana*) instead of conventional conifer species and gap cutting/chess-pattern cutting instead of clearcutting. In the eco-landscapes it is often possible to get figures of the cost of the measures, however the ecological effects of certain measures are seldom examined in a systematic way (but see also A. Larsson Ektröm et.al. 2021)

During the last decade or so, the larger forest companies have also increased their effort in reducing the negative effects of forestry on reindeer herding, e.g. by regularly leaving single trees or groups of trees with high abundances of epiphytic hair lichens, to serve as sources for re-establishment in the new, young stand and by adjusting the level or method of soil scarification in important grazing areas, to reduce the negative effects on ground lichens.

Parallel to the increased interest for restoration measures within the forestry sector, the need for active restoration measures within strict protected areas, to maintain or actively enhance development of conservation values, has also become more acknowledged and accepted. Today, the most used restoration measures within strict protected forests in the Biosphere Reserve are similar to those used by the forest companies within their stands set aside from production, e.g. measures to promote diameter growth and increase proportion of deciduous trees, to increase stand variation, re-wetting, creation of dead wood, prescribed burning and intentional harming of trees to mimic fire. However, also in the strict protected forests, the measures are not systematically designed and the ecological effect is seldom systematically monitored, except for some types of ecological effects for some types of measures. To further encourage the restoration effort in protected areas, the Swedish Forest Agency and the Swedish EPA have launched a program for active nature and culture measures in protected and set-aside forests (read more below).

To guide those who are working with conservation or restoration for biodiversity, the County Administration Board have made landscape analyses for different biodiversity conservation values. The resulting maps are public and communicated to stakeholders as part of the work with green infrastructure (GI) in the county of Västerbotten. These landscape analyses are today used both by authorities managing the strict protected forests, and the larger forest companies planning where to define eco-landscapes and preform restoration measures. However, the GI-landscape guides are rather coarse and focus solely on one or a few values at a time, and do not consider other potential values, such as functionality for reindeer herding, recreation, or tourism. Also, the GI-landscape guides are not well known among private non-industrial forest owners, who do not have ecological expertise “in house”, as many of the larger forest companies do. Thus, especially for forest owners other than the large companies, there is a need for more detailed guidance on where different kind of restoration measures might be suitable, both concerning biodiversity but also other forest services.

In addition to the knowledge and experience gathered among stakeholders outside academia, there are also several long-term research projects going on in the area examining the ecological effects and other aspects of different types of forest restoration measures. Some of these projects are led by researchers at SLU with a direct link to the Swedish SUPERB Demo area. Centrally situated within the Biosphere Reserve is also Svartberget and Kubäcksliden research parks, which is a center for forest field research in northern Sweden (*Vindeln Experimental Forests, 2022-12-16*). Within the same area is also Krycklan experimental area situated *(Hydrological Research at Krycklan Catchment Study, 2022-12-16)*. Overall, these research infrastructures provide long- and short-term trials and monitoring on stand development under various management treatments as well as on ecosystem conditions and responses. Experimental sites are compiled within the Silva Boreal database (Silvaboreal 2022-12-16). The Swedish SUPERB approach benefits from these existing resources in various ways.

At present, there are also several other initiatives and projects going on within the Biosphere Reserve that drives in the same direction as the SUPERB-project - towards ecologically, economically and socially sustainable forest management, adapted to the future climate. Four of these are extra worth mentioning:

- *Ett mer variationsrikt skogsbruk* (A more diversified forestry) (Ett mer variationsrikt skogsbruk - Skogsstyrelsen 2022-12-08) and its sister project *Nationell strategi för natur- och kulturvårdande skötsel av skogar som förvaltas med naturvårdsmål (*National strategy for Nature- and Culture Conservation Measures in Protected and Set-aside forests*)*, both 2020 – 2022. The first project focus on managed forests with the aim to increase the amount of deciduous stands and deciduous trees, more continuous cover forestry and more creation and caring for ecological and cultural values in the forest. Seminars,

experience- and knowledge-sharing in the field and by facilitating collaboration between interested forest stakeholders operating in the same region are part of the program set up. The latter project focus on measures within protected and set-aside forests. Contributing partners to the projects: Swedish Forest Agency, Swedish EPA, Swedish National Heritage Board, the County Administrative Boards, the forestry sector and NGO's.

- *Trees for Me*. Knowledge hub and platform for academia, government and industry/society. Focused on increasing the proportion of deciduous trees (Birch, Aspen and other *Populus* species) within conventional forestry, e.g. by investigating attitudes among forest owners and the public's towards deciduous trees in forestry, by examining how to manage deciduous trees and stands for biomass production and by working with plant nurseries/the plant breeding sector. (Trees-for-me homepage 2022-12-08)
- *World Forest Forum.* An initiative founded in Granö at the boarder to the Biosphere Reserve, investigating and promoting sustainable multi-usage of the forests, including potential new business models for forest owners. (The Swedish forest is a huge resource - World Forest Forum 2022-12-08)

All these different activities, initiatives, and research projects are contributing to the shared knowledge and experience with forest restoration, within the region and within the demo-area. The Swedish partner of the SUPERB-project will build upon this knowledge and experience, and is planning its activities within the demo area with the aim of creating synergetic effects together with the already ongoing projects and initiatives, as well as further contribute to, and develop, this joint knowhow in a way that empower forest restoration on a larger scale in the future.

1.2 Problems and restoration goals

To support value-chains and ecosystem services other than commercial timber and biomass production, the Vindelälven-Juhttátahkka demo-area will explore future forest and forest landscape management strategies that generate sustainability and multifunctional use.

1.2.1 Visions and goals

In general terms, the above-described human activities have led to a general landscape level reduction of biodiversity, ecological values and functionality, as well as reduced functionality for reindeer herding, caused by a loss and fragmentation of natural and semi-natural forests and reduction of landscape connectivity.

Although many actors within the forest community, such as forest companies, authorities, private forest owner associations etc. are aware of the problem and are working in different ways to halt this development, the Swedish Forest agency recently concluded that the negative trend are continuing and that the national environmental objective for forests are not met (Swedish Forest Agency 2022).

Therefore, the vision for the Swedish demo is to provide knowledge and regional incentives that helps to achieve the national environmental objective for forests stating that; the value of forests and forested land for biological production should be secured in parallel with protection of biological diversity and cultural- social values safeguarded.

On this basis, the overarching restoration goal is to promote the socio-cultural landscape context with focus on:

i. Connectivity and ecological functionality of forests and forest landscapes that harbour high biodiversity values and rich pools of ecosystem services, and
ii. Connectivity and functionality of habitats and migration routes for the indigenous Sami people reindeer husbandry.

More specifically, the restoration targets in the demo area include several objectives

- Alternatives to rotation forestry, i.e. diversification of forest management including continuous cover forestry, and re-creation of natural forest habitat attributes
- Restoration of riparian forest habitats in areas where in-stream restoration has been performed
- Restoration to support natural and cultural open and semi-open values in forest-dominated landscapes
- Restoration that support connectivity of forests with high conservation values
- Restoration that support landscape functionality and connectedness for reindeer husbandry
- An analysis of the role of restoration for supporting ecosystem services including recreation, tourism, local forest-based business and maintenance of cultural heritage

For all these aspects restoration that targets ecosystem services provisioning under future climate conditions, i.e. prestoration, is high on the agenda.

2 Current situation

2.1 Identified problems and challenges

Table 2.1 Identified problems and challenges, based on existing knowledge as well as the stakeholder meeting held in August 2022, sorted by the main cause of the problem.

Cause	Identified problem (Underlined numbers are addressed by actual physical restoration measures)	
Intensive harvesting of timber for a long time	1	A general lack of old-growth trees and dead wood at various decomposition stages
A forestry sector focused on conifer species, and a dominating use of a silvicultural scheme based on clear cutting, soil scarification, planting or sawing, pre-commercial thinning, two commercial thinnings and understorey cleaning before clear cutting again.	2	Even aged stands instead of stands with different age classes, cohorts (pine dominated stands) or uneven-aged stands (spruce dominated stands)
	3	Structurally homogeneous stands instead of heterogeneous
	4	Low tree-species diversity within stands
	5	Lack of deciduous trees within conifer-dominated stands, especially older and coarser individuals
	6	Reduction of ground lichens in areas with heavy soil scarification
	7	Reduction of stands with high amount of tree-living, pendent lichens
	8	Loss of mycorrhizal fungi, that are dependent on a continuous tree cover
	9	Increased nutrient and particle runoff from the forest to streams, caused by the removal of most trees and by mechanical vehicle damage/soil scars in the riparian zone
	10	Dysfunctional riparian- and protective zones along waterways: a) Not adjusted for the actual site (e.g., too narrow) b) Not giving enough shadow (especially important at small streams) c) Lack of old enough trees that soon will contribute with dead wood in the stream d) Lack of deciduous trees that will contribute with leaf litter and detritus in the stream
	11	Fragmentation of forests with high conservation value/high biodiversity value

Large scale use of *Pinus contorta* for biomass production	12	Reduction of natural ground vegetation within stands, including ground lichens
	13	*P. contorta* stands are dense and reindeers avoid this stands while migrating
	14	Potential of becoming invasive; unwanted regeneration and dispersal outside planted stands. Extra problematic near protected areas
Systematic depression of forest fire on a landscape level, for a long time	15	Denser pine forests due to more understory growth by spruces, which normally would have died if the forests would have burned regularly. → Less suitable forests for ground lichens
	16	Lack of pines with fire scars. Harm, preferably by fire, changes the structure and chemical traits of the pine wood giving them a better defence and a higher probability of becoming really old.
	17	Lack of deciduous-dominated stands
	18	Lack of habitats for fire-dependent species
Systematic channelling of water streams for timber floating	19	Reduced connectivity between forests and streams, manifested as a) Lack of dead wood connecting land and water b) Reduced areas of periodically flooded areas (fluvial forests) c) Lack of deciduous dominated stands along streams
Systematic ditching and lowering of lakes in the forested landscape	20	Lack of swamp-forests and other wet forest types
	21	Increased and faster runoff from the forested landscape to the streams, increasing the risk for flooding down-streams.
	22	Increased nutrient and particle runoff from the forest to streams

Climate change: increased risk for warmer periods during winter	23	Increased risks for “locked” grazing areas for reindeers during winter → increased costs for Sámi villages as they must buy and distribute extra fodder → Increased risks for health problems among reindeers as they must eat fodder they are not used to and are gathered closer together than usual, increasing risks for diseases to spread
Climate change: Shorter and more unsecure ice conditions at rivers, streams, and lakes	24	Difficulties for reindeers and reindeer herders to follow natural and traditional migrating routs → Increased costs and work for samebys, and more stressed animals as reindeers must be transported by trucks → Increased risks for drowning incidents by animals and people
Climate change: Reduced effects of land up-lift due to increased sea level	25	Reduced establishment of primary successional forests along the coast, especially deciduous dominated forests.
Climate change: climatic zones are shifting northwards and upwards in an ecologically high speed	26	Species need to be able to follow ”their” climate zone. This requires a functional network of suitable habitat for each species.
Intensifying and centralisation of farms	27	Reduction of species rich open (grassland) areas within the forested landscape.
Lack of possibilities for governmental landscape planning	28	Difficulties and lack of incentives to plan restoration and management strategies on a landscape level, and for forest owners to cooperate and coordinate management over owner boundaries

3 Restoration activities and initial assessment

To reach the overarching goals of the Vindelälven-Juhttátahkka demo-area, and to head towards the vision of the project, we will apply different kinds of interventions.

3.1 Synthesis of methods and sites for restoration used in the region

Information on used and tested forest restoration measures and alternative forest management schemes from northern Sweden will be collected and compiled during the SUPERB-project.

3.1.1 Aims

- To serve all stakeholders that might be interested in forest restoration in the northern parts of Sweden with a list (and potentially a map) with information on different suitable forest restoration measures that might be used in the area, also including a presentation of ongoing research experiments and sites.
- To produce easy-to-understand instructions for some of the most used and verified measures, to be used by forest owners and other potential users.

3.1.2 Problems addressed

Unknown, it depends on the outcome of the synthesis.

3.1.3 Implementation

The information will be gathered continuously during the project in contacts with forest owners, authorities, universities and other stakeholders. Some active searching will also be done, but not systematically. Information that will be collected include:

- Site (name and coordinates)
- Actor
- Landowner
- Description of measure
- Aim
- Targeted forest type
- Possibility to follow-up (does reference or baseline-data exists?)
- Area
- Year of establishment
- Financing
- Cost

The results will be presented in a list/table and potentially also an interactive map.
For some of the most common, or most effective measures easy-to-understand instructions will be produced.

3.2 Landscape advisement-campaign for sustainable forest management

In a minimum of 5 and a maximum of 12 landscapes, approximately 10 000 – 20 000 ha large and evenly located among reindeer herding communities and municipalities, we will invite concerned forest owners (especially private / non-commercial) to field excursions and indoor workshops/information meetings. Each landscape will be centred around a place where the SUPERB-project, or another actor, has carried out ecological restoration measures and/or carried out alternative, and more lenient forest management practices. Before the indoor activities, we will analyse the landscape by GIS to identify both core areas for different forest values and what key functions and values that is lacking or problematic in the landscape to reach ecological function and connectivity as well as a better functionality for reindeer herding. The analysis will also include suggestions on how the landscape could be managed, both including restoration measures in set-aside areas as well as alternative management practices in the productive forest. During the indoor activities we will use the analysed maps as base for the discussions.

3.2.1 Aims

- To increase awareness and interest among forest owners and managers to manage their forests sustainable. This will include both alternatives to rotation forestry in productive stands and the practice of restoration measures, with a focus on increased ecological functionality and sustainability for other ecosystem services. It will also include discussions on incentives for alternative forest management schemes and restoration measures.
- To enhance dialog among forest owners and other stakeholders within a certain delineated landscape and enhance capacity for landscape planning.
- To serve the forest owners within the landscape with a voluntary plan on how they can manage their forest in an ecological, economical and socially sustainable way, within a landscape context. The plan and the material connected to the plan, e.g. maps and other attachments, shall be easy-to-understand and to embrace for any stakeholder within the landscape.
- To serve the forest owners within relevant geographical information (maps) on how they can manage their forest in an ecological, economical and socially sustainable way, within the context of the delineated landscape. The maps and the material connected to the maps, e.g. instructions and other attachments, shall be easy-to-understand and apply for any stakeholder within the landscape.
- To prepare for potential future upscaling by strategic, tactical and operation approaches that involve governance, management, planning and participatory components.

3.2.2 Addressed problems

See table Table 2.1.

3.2.3 Implementation

The work will start by selecting and geographically delineate suitable landscapes*, based on where we can find good examples of already carried out restoration, existing landscape analyses of ecologically valuable forest landscapes and in dialog with the Sámi villages and

other regional stakeholders. (*the location of three landscapes is pre-determined by the location of the planned restoration measures, see below)

Next, a more detailed analyse will be done in each landscape, both identifying what key functions and values that is lacking or problematic and what values that are present and can be built upon to reach a more sustainable forest management in the area, today and also considering a changed climate. This analysis will include both different kind of GIS-data, such as data from the County Administration Board on likely CCF-stands, data from the forest companies and the Kub-AI model[1].

In up to six landscapes each year, we invite the concerned forest owners (and potentially other stakeholder, to one field excursion and one indoor meeting. During the field excursion we will visit stands that has been restored or where alternative forest management practices has been caried out and together discuss different practical and other aspects of the measures. The indoor meeting will be a chance to inform the forest owners on what is going on around restoration at national and international level, present different kinds of measures, talk about incentives and ongoing initiatives and ideas for financing. The indoor meeting will also include a workshop where we use the maps from the landscape analysis as base for discussions on what could be done where for more sustainable forest management.

The actual meetings, both field excursions and indoor meetings, will be carried out in collaboration with the Swedish Forest Agency's regional advisers on Continuous Cover Forestry and hopefully also Norra Skog - the regionally dominating association for private forest owners, which also have an important advisory role for private forest owners.

Finally, the maps, including instructions and potential attachments, will be made easily available for the forest owners to facilitate the use of the maps in their future forest management.

[1] A wall-to-wall model that provides the relative probability that a forest area (1 ha scale) has high conservation value. The model has been derived by Machine learning and based on a manuscript currently under scientific review.

3.3 Description of restoration activities

Actual, physical restoration measures will be performed within three of the landscapes (Figure 3.1), for which we also will do detailed landscape analyses of conservation values. The physical measures will be conducted in the core areas of these landscapes, in which the Vindelälven-Juhttátahkka demo-area has agreements with the concerned forest owners. The three landscapes represent different forest conditions, management histories as well as differences in ownership and potential external interests for multifunctional use.

3.3.1 Aims

- To create demonstration areas for different restoration measures.
- To implement restoration measures in a controlled way that enables follow up on the outcome of the measure, both on important structures and on ecological responses.
- To test new types of measures

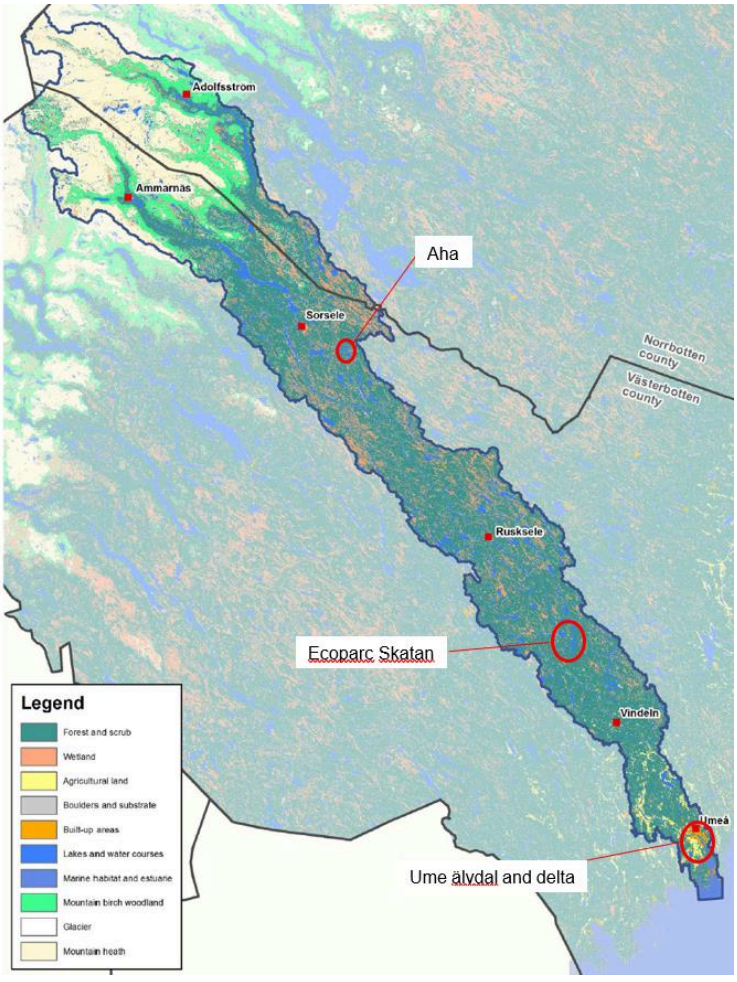

Figure 3.1 Location of the three landscapes where actual physical restoration measures will be performed.

3.3.2 Problems addressed

Problems marked with an underlined number in Table 2.1 might be addressed (which exact problems will be addressed will be known later, when more exact stands for restoration measures are defined together with the forest owners)

3.3.3 Implementation

The focus for the actual restoration measures will be different in the different landscapes. Below, the core areas of each landscape, in where the actual restoration measures will be performed, is presented with an overview. Later, when more exact stands for restoration measures are defined together with the forest owners, more detailed descriptions and goals will be presented for each specific stand/restoration measure.

Landscape: Ume älvdal (lower river-basin) and delta

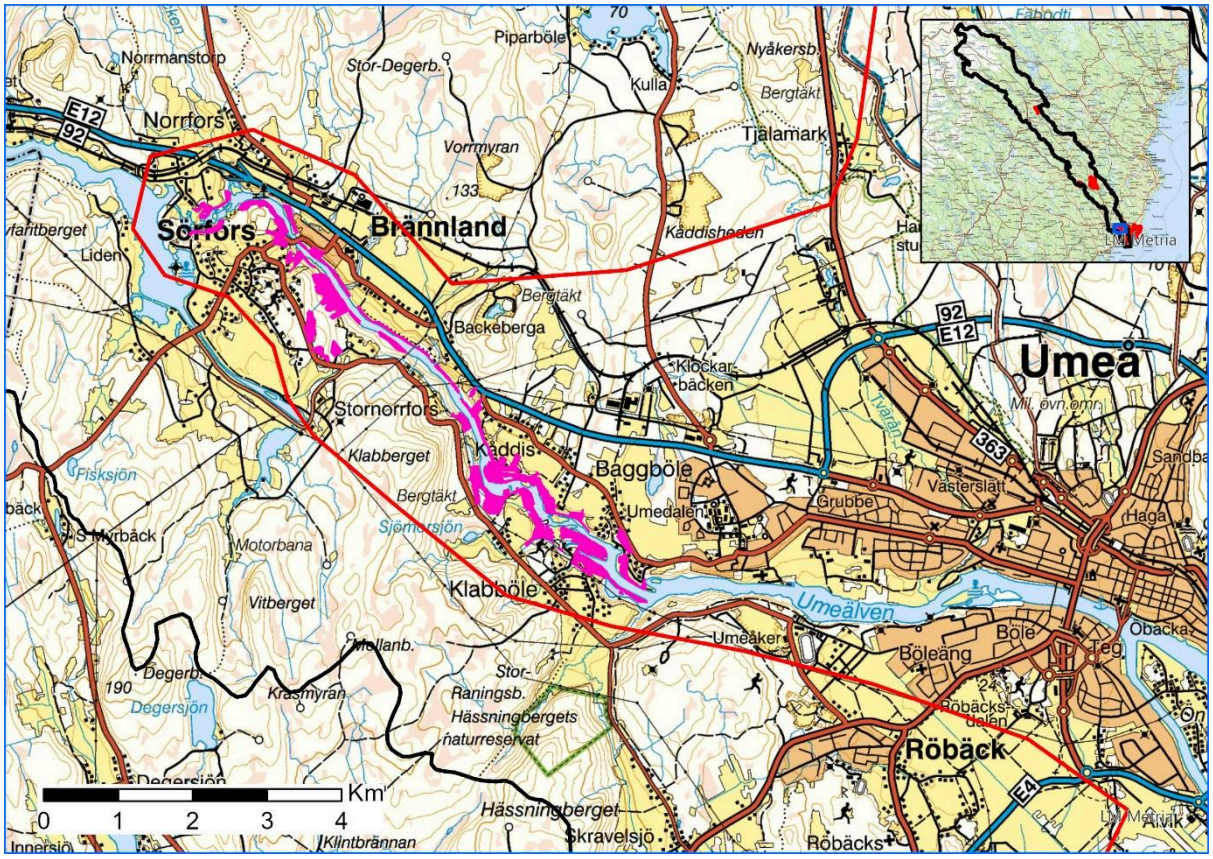

Figure 3.2 Location of stands where actual restoration measures might be performed (pink areas), within the Ume älvdal and delta-landscape. Red line indicates approximate outline of the landscape, before planned landscape analysis. Black line indicates outline of the Vindelälven-Juhttátahkka demo-area.

Table 3.1 Short facts about the Ume älvdal and delta restoration landscape

Short facts: Ume älvdal and delta	
Location	0,5 - 7,5 kilometres west from Umeå city, capital of Västerbotten county
Ownership of forest properties open for restoration	Umeå municipality and private
Restoration focus	– Restoration/establishment of deciduous-dominated stands and deciduous-promoting measures within conifer-dominated stands. Focus species: White backed woodpecker (*Dendrocopos leucotos*). – Special focus on function for recreation and out-door living close to an urban area/city
Targeted forest types	Mainly 9010 *Taiga*, subtypes *natural old deciduous forests* and *natural old mixed forests* but also 9030 *Natural forests of primary succession stages of landupheavel coast.*
Examples of measures that might be carried out	– "Girdeling" bark removal on most spruces and pines in deciduous rich stands. Aim: Create a more open and lighter deciduous dominated stand by slowly and

	successively killing the coniferous trees. Creates dead conifer wood in the stand. - Cutting and removal of most spruces and pines in deciduous rich stands. Aim: Create a more open and lighter deciduous dominated stand. Might be used in stands with large number of spruces where it might be a risk for bark beetle outbreaks if the fresh wood is left within the stand. Implicates an income for the forest owner. - "Girdeling" bark removal on deciduous trees. Aim: create dead deciduous wood by slowly killing the trees and hence providing resources for white-backed woodpecker. - Fencing. Aim: to limit moose and other animals from grazing on the deciduous trees. - Selective thinning in young, deciduous dominated stands. Aim: To create more variation in stem density, promote species of higher conservation value (e.g. Goat willow and Aspen), increase growth in selected individuals.

Landscape: Skatan

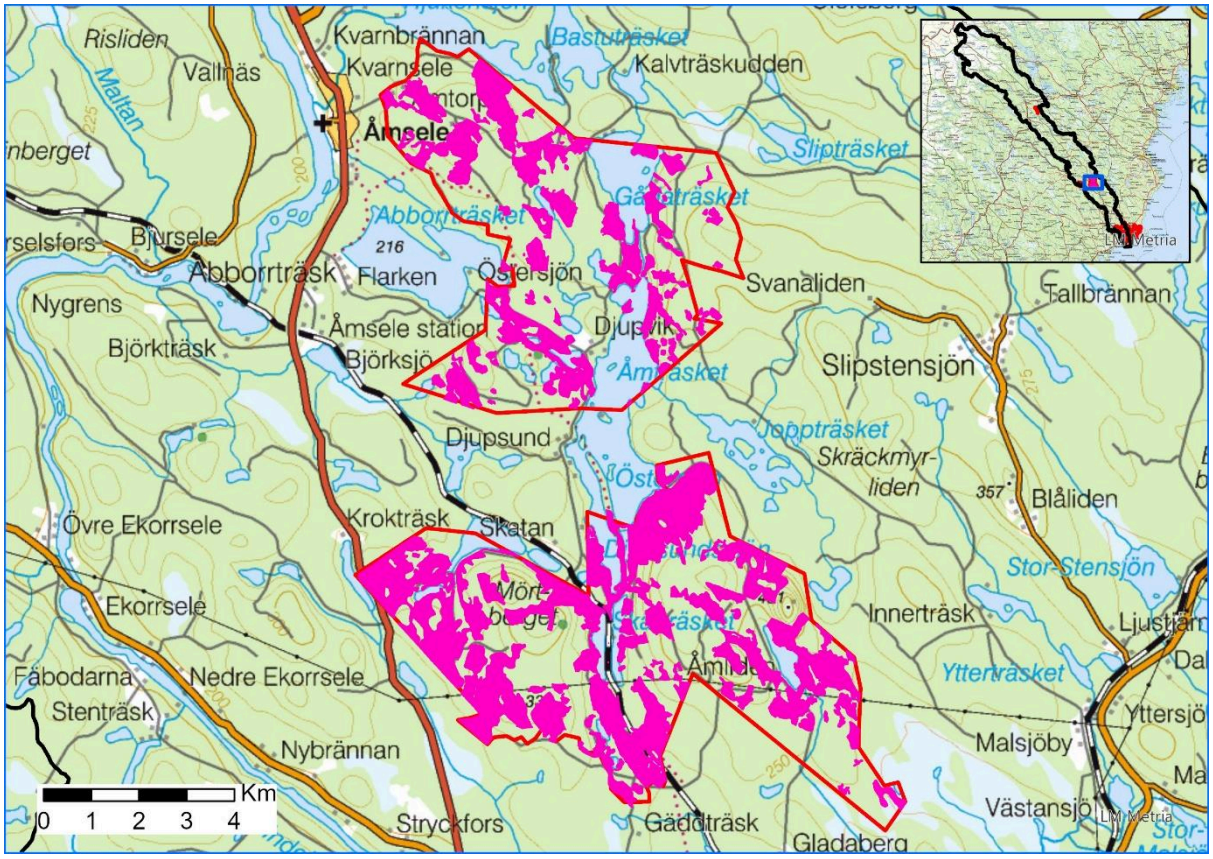

Figure 3.3 Location of stands where actual restoration measures might be performed (pink areas), within the Skatan landscape. After agreement with the forest owner, a subset of the available areas will be restored. Red lines indicate outline of the Skatan Ecopark in which the forest owner Sveaskog are carrying out forest management with extra focus on biodiversity and outdoor life. Black line indicates outline of the Vindelälven-Juhttátahkka demo-area.

Table 3.2 Short facts on Skatan Ecopark restoration landscape

Short facts: Skatan Ecopark	
Location	Appr. 20 km N from Vindeln society and 30 km SSE from Lycksele city.
Ownership of forest properties open for restoration	Sveaskog (State owned forest company)
Restoration focus	– Re-create and re-establish typical forest structures and elements, characteristic for natural conifer-dominated forests and landscapes, both connected to pine forests and spruce forests, including promoting development of deciduous species – Improve the landscape function and connectivity for reindeer herding – Re-establish mowing or grazing on earlier mowed and unfertilised grassland in connection with forestland. Adjusted management of edges between forests and open areas to improve its function for biodiversity and connectivity, especially for pollinating insects.

Targeted forest types	Mainly 9010 *Taiga*, with all subtypes except *recently burned forest*, but also 9070 *Fennoscandian wooded pastures*.
Examples of measures that might be carried out	Pine dominated/naturally fire-disturbed stands: – Selective thinning (all spruces and selected pine trees). The timber could be removed of left within the stand to become dead wood. Stems could be cut or tipped over. Aim: To create a less dense stand with higher spatial variation in stem distribution. Create better condition for ground lichen growth. – Intentional, mechanical harming of selected pine trees, veteranization. By using chain saw, handheld cutter or by running the harvester head up and down but without cutting. Aim: To create harmed but living pine trees with wood that better withstand insects and wood decaying fungi. – Controlled burning in small or larger scale. Aim: to create burned wood, harmed but living pine trees, dead wood, ground disturbance, promote establishment of deciduous trees etc. Spruce dominated stands: – "Girdeling" bark removal or intentional harming of individual or smaller groups of spruces. Aim: create dead spruce wood by slowly and successively killing the trees. Create higher variation in stem density. Create small scale openings to allow establishment of seedlings and thereby a wider age distribution. – Felling of individual or small groups of spruces by either cutting or tipping over the trees. Aim: create instantly dead spruce wood, vertical and horizontal heterogeneity. Create higher variation in stem density. Open up for establishment of seedlings and thereby a larger variation in tree age. – Selective clearing of spruces around individual or groups of intermediate to large deciduous trees. Might be done by cutting or by "girdeling" bark removal. Aim: Improve living conditions for epiphytic species living on the deciduous trees, improve diameter-growth for individual deciduous trees, open for potential new sprouting of aspen-clones Enhancement of conditions for reindeer herding: – Earlier-than-usual pre-commercial and commercial thinning in pine stands to promote ground lichen growth. – Removal of contorta stands. – Re-establishment of ground lichens after ground disturbance by distributing lichen fragments. – Re-establishment of pending lichens in young stands by distributing lichen fragments. (Experimental measure) Boarder-zones between closed forests and open land – Preparations for forest grazing: Establishing contact and agreements with nearby animal stockholders. Cutting (and removal or gathering in piles) of bushes and individual trees to enhance grazing quality. Fencing. – Improvement for biodiversity along forest roadsides, especially for flowering plants and pollinating insects: Selective clearing of vegetation along the roadsides, saving individual deciduous trees to become old and large,

	especially the species Goat Willow, Rowan and Bird cherry (*Prunus padus*) that provide flowers to pollinating insects and berries for birds. Creation and maintenance of patches with bare sand or soil and leaving/providing coarse dead wood to the roadside. Removal or piling of thin dead sticks and stems that are produces while cutting the roadside vegetation.

Landscape: Aha

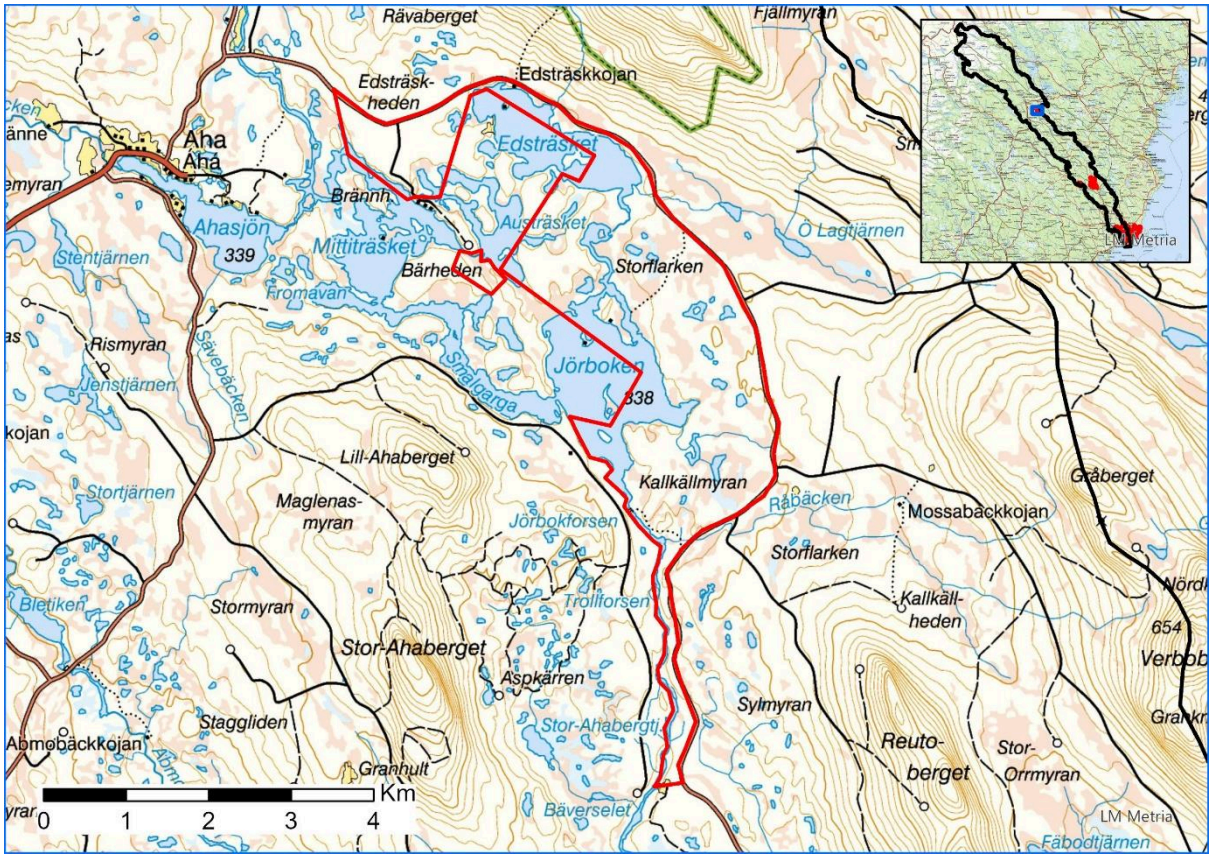

Figure 3.4 Location of property in the core of Landscape Aha, where actual restoration measures might be performed (Red lines). Black line indicates outline of the Vindelälven-Juhttátahkka demo-area.

Table 3.3 Short facts on the Aha restoration landscape

Short facts: Aha	
Location	Appr. 15 km SE from Sorsele society.
Ownership of forest property open for restoration	Skogssällskapet (public service foundation whose main objectives are to ensure sustainable forest and land management)
Restoration focus	– Improve connectivity and ecological function of the forested buffer zone in connection to a natural river/water course – Re-create and re-establish typical forest structures and attributes, characteristic for natural conifer-dominated forests and landscapes, especially to pine forests and in stands of young age. – Special focus on function for recreation and out-door living outside urban areas, such as fishing, hunting, berry- and mushroom picking.

Targeted forest types	9010 *Taiga*, with all subtypes. Important structures and functions for 3210 *Fennoscandian natural rivers* and 3260 *Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation*
Examples of measures that might be carried out	Pine dominated/naturally fire-affected stands: – Selective thinning (all spruces and selected pine trees). The timber could be removed of left within the stand to become dead wood. Stems could be cut or tipped over. Aim: To create a less dense stand with higher variation in stem density. Create better condition for ground lichen growth. – Intentional, mechanical harming of selected pine trees. By using chain saw, handheld cutter or by running the harvester head up and down but without cutting. Aim: To create harmed but living pine trees with wood that better withstand insects and wood decaying fungi. – Controlled burning in small or larger scale. Aim: to create burned wood, harmed but living pine trees, dead wood, ground disturbance, promote establishment of deciduous trees etc. The riparian zone along small river Gargån and other streams – "Girdeling" bark removal or harming of selected large trees, mainly spruces, along the side of the stream. Aim: create a successive supply of dead wood into the stream. Create gaps along the stream to enhance understory growth. Increase the proportion of deciduous trees in the riparian zone. – Filling/plugging ditches that are discharging directly into the stream. Repairing any mechanical vehicle damage/soil scars in the riparian zone. Aim: To reduce nutrient and particle leakage into the stream.

3.4 Initial assessment of restoration sites (where actual restoration takes place)

Which parameters and protocols that will be used for baseline and follow-up assessments will be determined by the goals for each specific stand and measure. Therefore, the goals for each restoration stand will have to be clearly defined and described:

A. A description of the targeted nature type, e.g., 9010 *Taiga*, subtype *natural old pine forests*, and what special characteristics of that specific nature type that the restoration are meant to provide/increase/improve.
B. A description of the expected development of the stand after restoration measure/s, including an approximated "delivery time-line" of both structures and ecological response.
C. A description of what practical/technical specifications that should be met directly after the measure. This should be the base for what is communicated to the practitioners/entrepreneurs that will perform the actual measure and will thus also be the base for the technical/practical and economic evaluation against entrepreneur contracts, after the measure is compleated. For example: "After restoration there should be xx stems per ha, unevenly spaced, and the proportion of deciduous trees

should be between xx and yy %. Goat willow and Aspen should be chosen before birches."

3.4.1 Parameters and sampling-design

The sampling-design and measured parameters will be based on the *Protocol for Regular forest inventory* produced by the SUPERB WP6, in combination with national guidelines and protocols for monitoring Natura 2000 – nature types (Gardfjell & Hagner 2019 and Natura 2000 i Sverige (naturvardsverket.se), 22-12-19). The design and choice of parameters will be customised both to be able to pick up general responses of restoration, independent of planned/used restoration measure, but also be partly flexible to be able to pick up specific responses that is relevant to the specific goals of each restored forest stand. Also, other sampling designs and parameters than those present in protocol for *Regular forest inventory* and national guidelines and protocols for Natura 2000–nature types might be used to pick up responses connected to other expected ecosystem services, such as importance for reindeer herding or out-door life.

The sampling-design and choice of parameters will be developed during 2023 Q1 in collaboration with the task 6.3-team, after the more specific goals have been set for each planned restoration-stand.

4 Monitoring

4.1 Site and stand selection for Monitoring, Reporting and Verification of Biodiversity and Ecosystem Services in chronosequence

The Vindelälven-Juhttátahkka demo-area is one of six demo-areas where an extended biodiversity assessment should be carried out, including 1) soil sampling for carbon and biological activity, 2) collection of biological material for metabarcoding (above-ground insects and soil organisms), 3) bioacoustics recording, 4) remote sensing and 5) regular forest inventory.

Plots for collecting data were selected from the Krycklan catchment experimental area (see info-box). In total, 37 plots (Figure 4.1, attachment 1) were chosen among more than 400 available plots, with known data on e.g. soil parameters, vegetation, tree species proportions, site fertility, stand age, and total stem volume per ha. The site and plots were selected in dialogue with the task 6.3-team.

Krycklan catchment experimental area & Vindeln Experimental Forests

Krycklan is a 6780 hectare catchment where the relationships between hydrological, biogeochemical, and ecological processes has been studied in the same ecosystem since 1980. It is one of the most instrumented and monitored watersheds in the world. (Hydrological Research at Krycklan Catchment Study 22-12-16)

Krycklan is part of the SLU Vindeln Experimental Forests (Vindeln Experimental Forests, 22-12-16), with Svartberget research park as the center for all experimental forests, situated in the center of Krycklan. Svartberget is equipped with infrastructure and technological competence for ecosystem research and a part of the Swedish Infrastructure for Ecosystem Science (SITES), thus offering a broad spectrum of different kind of available data on the monitored stands.

The selected plots represent two series, one for pine dominated forests and one for spruce dominated forests, as these are the two main forest types in the Vindelälven-Juhttátahkka demo-area and boreal forests in general. Within each serial, the plots were selected to represent an age-gradient, from 23 – 225 years stand age for pine, and 27 – 197 years stand age for spruce. Except from the plots with oldest tree age, most of the plots are situated in standard managed forest, meaning that the forest (especially plots in ages up to approximately 70 years), often are the result of clear cutting, soil scarification, planting, and one or more thinning events. No active restoration, with purpose of increasing biodiversity, has been done in any of the plots. Thus, most plots in these two series (excluded the oldest plots and some plots in more mixed stands) represent stand development following clear-cutting. The oldest plots should instead be seen as the reference ecosystem areas, together with some of the younger, but more naturally developed plots (Figure 4.2).

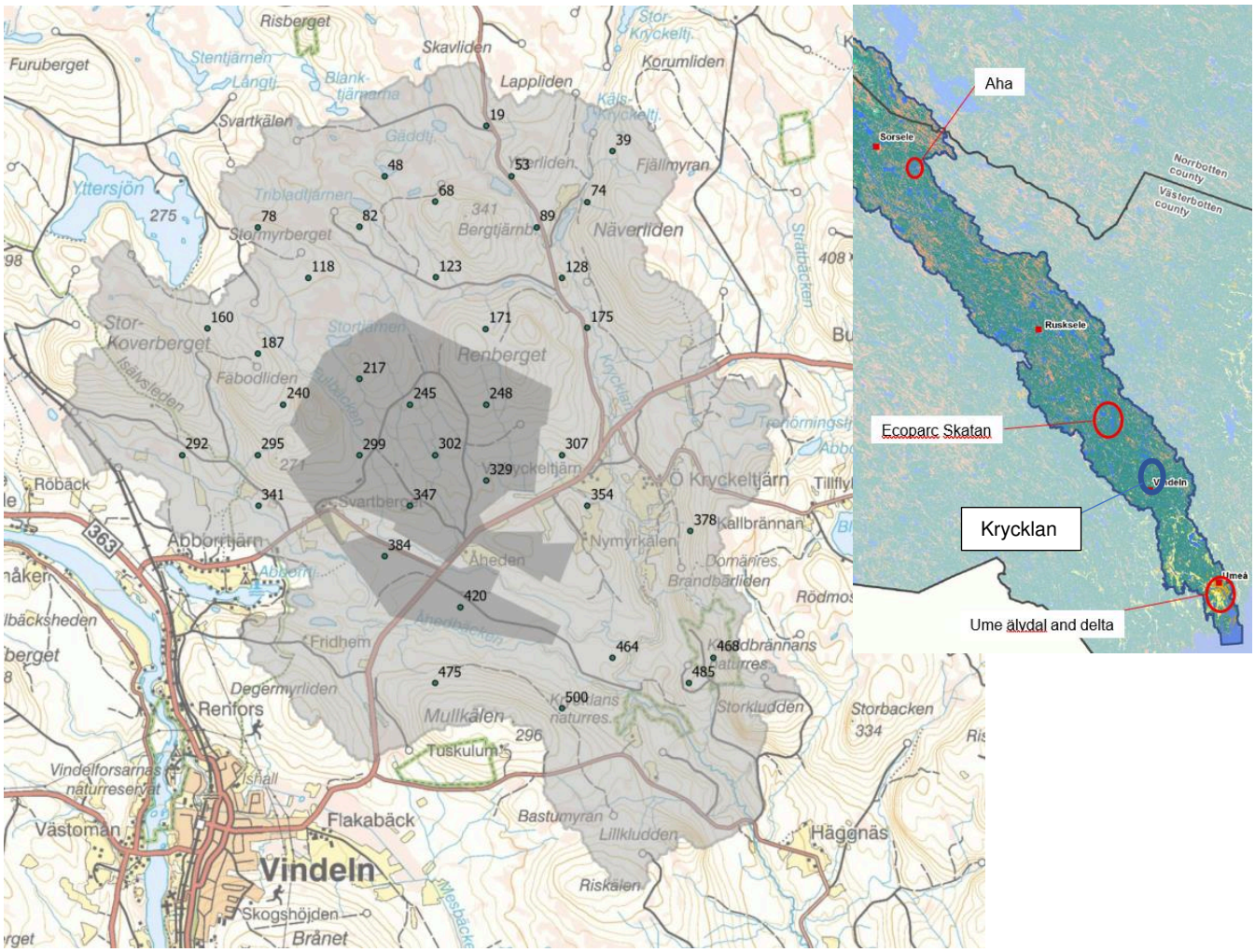

Figure 4.1. Krycklan catchment area (lighter gray area) with Svartberget field research facilities in the center.(darker gray area). Location for selected plots indicated with green points and numbers.

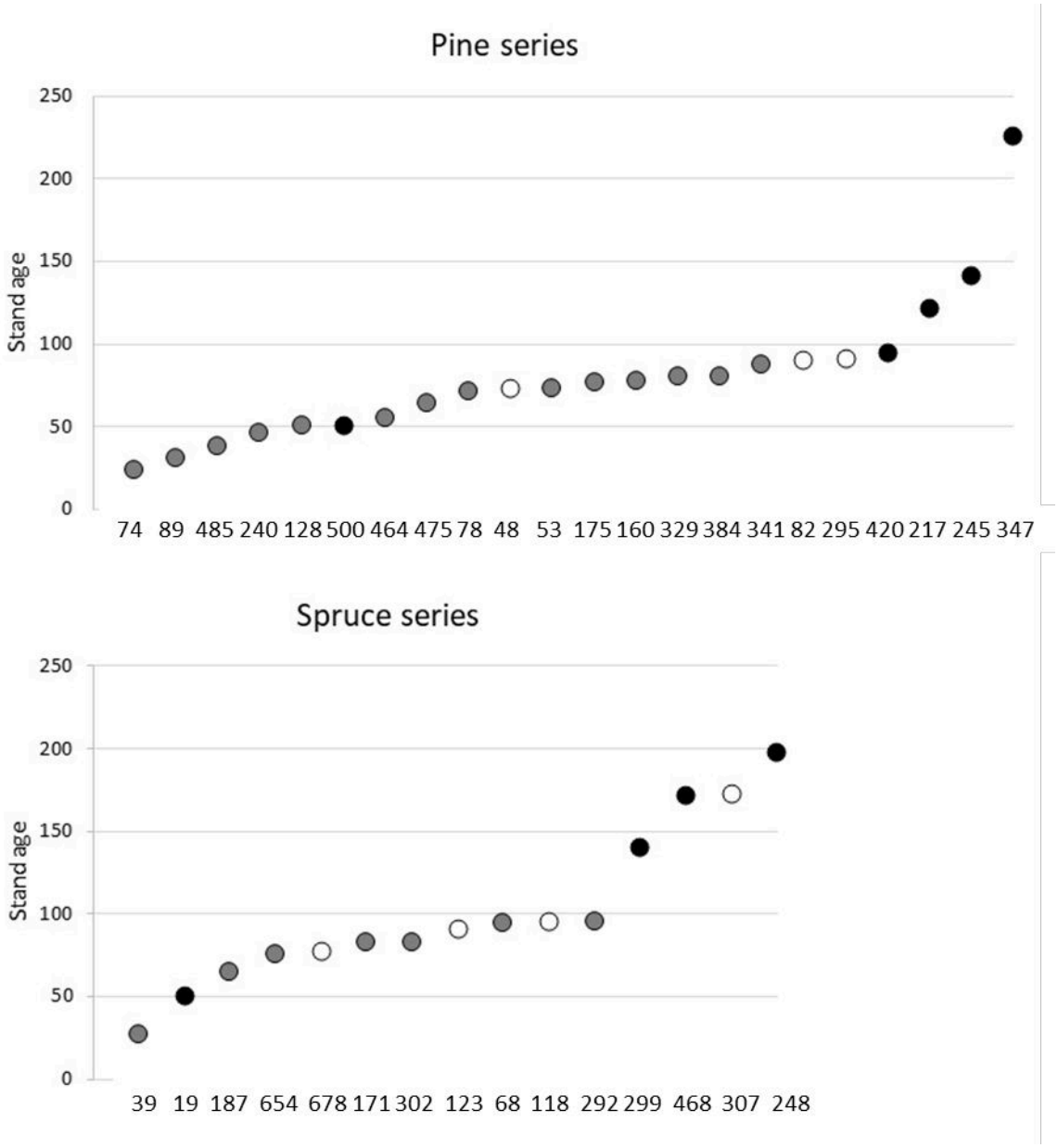

Figure 4.2 Stand age distribution of the pine and spruce plot-series as a chronosequence of stand development from young to mature stages, with reference ecosystem plots (black) and recently thinned plots (white; as interpreted by data) indicated. In the pine series, plot 500 is considered as reference based on tree species mixture (as also spruce, birch, aspen and other deciduous tree species occurs at 10% or higher proportion of the basal area), plot 420 based on volume dead wood (19.5 m^3) and volume living trees 329 m^3), and plot 217, 245 and 347 based on stand age (121 to 225 years). Plot 347 also has substantial (<25% of basal area) presence of spruce and birch. In the spruce series, plot 19 is considered as reference based on tree species mixture (birch, aspen and other deciduous tree species occurs at 10% or higher proportion of the basal area), plot 299 on age (140 years) and stem density (1083 stems per ha), plot 468 on age and volume living trees (171, 433), and plot 248 on age and volume living trees (197, 602). Plot 307 has been recently thinned.

4.1.1 Description of monitoring measures

Plot based forest inventory
Over the three forthcoming years, regular plot-based inventory of trees is conducted once in several inventory plot for evaluation of the success of natural regeneration. It includes identifying causes of tree mortality, and assessment of biodiversity. For ground vegetation, we mainly follow the ICP Forest guidelines (Canullo et al. 2011), which in short means that herb layer species richness and abundance is assessed. Temporal replicates are not needed for regular forest inventory work, so the data are acquired during a short campaign. It would be desirable to also survey tree-related microhabitats as indicators for the potential presence of certain taxa of forest-dwelling species. This survey, which follows a catalogue developed by Kraus et al. (2016), is an optional component. In addition, data on non-tree species are collected using iNaturalist app, to compare the benefit from citizen science approaches in ecosystem regeneration projects. See protocol below for more information.

Soil carbon and soil biological activity
In all inventory plots a single assessment of soil carbon and soil biological activity/diversity takes place in the first two years of the project. For this purpose, the KU Leuven team is carrying out the soil sampling.

High-throughput biodiversity data: DNA metabarcoding & bioacoustics
In addition, sampling of flying insects, soil fungi and plants, bioacoustics recording of animals takes place each year because these are taxonomic groups that most likely show a rapid response to restoration activities. Used approach requires that surveying and sampling are more spread in space and time over each of the three years. The reason for carrying out campaigns over several years is to capture temporal variability in the abundance and activity of different species, and to assess the effectiveness of methods employed to assess biodiversity. This enable a power analysis to determine the level of evidence that the sampling scheme can prove. Soil samples are collected during a single field visit, but acoustic recordings require at least a week, and we are limited by the number of recorders we can provide. Malaise traps do not require maintenance before collection but should be deployed for a minimum of one week.

Remote sensing
Finally, multispectral drone surveys and ground-based LiDAR surveys is carried out once over the project time spam.

4.1.2 Planning of monitoring

The first round of data collection for the Vindelälven-Juhttátahkka demo-area were done in the summer of 2022. Collection of biological material for metabarcoding as well as recording of bioacoustics (task 6.3) were done during June 12 to July 7, whereas collection of soil samples for assessing carbon and biological activity (task 6.4) were done August 8 to 21. All collected material were sent to Bangor University, UK, for further analyses. The planned remote sensing was also carried out 2022.

During the two coming field seasons (summer of 2023 and 2024) the collection of biological material for metabarcoding as well as recording of bioacoustics (task 6.3) will be repeated.

The regular forest inventory in the selected Krycklan-plots will also be carried out during field season 2023 or 2024, following the same sampling-design and protocols that are developed for the restored forest stands (see above, 4.1.1).

5 Stakeholders

5.1 Performed and planned activities for communication and stakeholder involvement

5.1.1 Performed activities

- Meetings with the advisory group
- Stakeholder mapping (Task 2.1)
- 1st stakeholder workshop with the regional reference group (Task 2.4)
  (*The information and suggestions that came out from the first stakeholder workshop has been considered and incorporated in this workplan, especially in the description of the problems and in the design of the planned restoration activities.*)

- Sharing information and news about the SUPERB project at regional conferences and gatherings and through the communication channels of the Regional forest program and the Biosphere Reserve, such as web sites and social media.

5.1.2 Planned stakeholder actions

- Development of a communication plan (Task 2.3), including e.g.,
  - Public presentations of the project, both in the beginning and in the end of the project
  - Distribution of a short, digital "newsletter" to interested stakeholders on a regular base,
  - Collaboration with the communicators at SLU and County Administration Board to involve them in spreading news about SUPERB via their channels.
  - And potentially more…
- 2nd and 3rd stakeholder workshop with the regional reference group (Task 2.4)
- Regular meetings with the advisory group (3/yr)
- Continuous contact with different groups of stakeholders, in addition to the stakeholder workshops planned for task 2.4.
- Workshops, field excursions or other types of involvement of local stakeholders during the planned Landscape advisement-campaign.

5.2 Restoration activities based on stakeholder workshop

Several of the planned activities within Vindelälven-Juhttátahkka demo area are directly influenced by the response and comments from the stakeholder workshop, e.g. the activity *Synthesis of methods and sites for restoration used in the region*, which will result in a list of suitable restoration measures, places to visit to learn more about the measures, as well as simple instructions for forest owners on how to carry out the measures.

The planned *Landscape advisement-campaign for sustainable forest management* is another example of an activity with aims that has been formed on the base of what came out from the stakeholder workshop. This activity meat several of the responses, e.g. the need to communicate potential benefits of restoration to forest owners, to communicate and discuss alternative economical outcomes from the forest and the experienced opportunity to succeed if different organisations and stakeholders come together around restoration as a common interest.

Also, the list of identified problems and challenges, which is the base of the planned restoration measurers and other activities, is partly based on what came out from the stakeholder workshop.

5.3 Restoration goals based on stakeholder workshop

Following the first stakeholder workshop from the Czech demo-region, the surveys on ecosystem targets were responded by 3 stakeholders. According to these, the most relevant ecosystem services to be provided by the forests to restore are (1) production of raw materials; (2) habitat provision; (3) disturbance regulation; (4) food production; (5) recreation; and (6) cultural services (Figure 5.1 Ecosystem services that the restored forests should provide according to stakeholders. In the surveys, they were provided a list of generic ecosystem services, from which they were asked to select the 5 most important. The vertical axis indicates the frequency upon which a certain ecosystem service was considered relevant. Only ecosystem services with at least one selection are displayed.Figure 5.1).

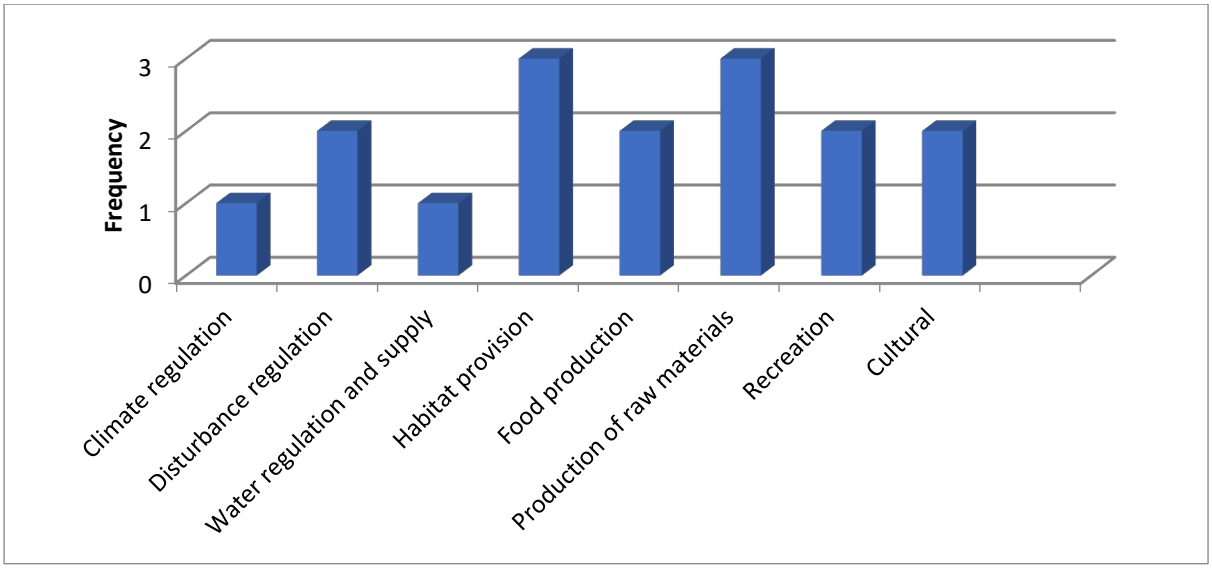

Figure 5.1 Ecosystem services that the restored forests should provide according to stakeholders. In the surveys, they were provided a list of generic ecosystem services, from which they were asked to select the 5 most important. The vertical axis indicates the frequency upon which a certain ecosystem service was considered relevant. Only ecosystem services with at least one selection are displayed.

The target ecosystems are described as structurally and compositionally diverse forests, integrated in a mosaic of varied land uses. Reindeer husbandry is seen as a vital activity for local communities, and any landscape or stand-level setting that hinders it, should be incompatible with the target ecosystem. Meanwhile, promoting the development of mixed-species forests, mostly with climate-adapted species and through natural regeneration, and increasing structural complexity, are seen as adequate measures for making local forests more adaptive to global change.

6 Planning

Table 6.1 Planning per year

Action	2022	2023	2024	2025
Restoration activity: Landscape advisory campaign	Q4: * Gather relevant stakeholders as well as geographical information to identify and delineate suitable landscapes for further analysis.	Q1-Q2: * Perform landscape analysis in a subset of the delineated landscapes. Q2: Start inviting forest owners to meetings Q3-Q4: * Arrange field excursions and indoor-meetings for forest owners in collaboration with SFA	Q1-Q2: * Perform landscape analysis in the rest of the delineated landscapes. Q2: Start inviting forest owners to meetings Q3-Q4: * Arrange field excursions and indoor-meetings for forest owners in collaboration with SFA	
Restoration activity: Synthesis of restoration measures	Q4: Set up a system for organizing the collected information and a plan for relevant stakeholders to contact	Continue to collect information.	Continue to collect information. Q3-Q4: Production of easy-to-understand instructions for some restoration measures	Publish the information in an easily accessible way e.g., a searchable/sortable table or a map
Restoration activity: Physical restoration measures	Q4: Plan details of the physical restoration measures	Q1: Plan details of the physical restoration measures Q2-Q3: Arrange practical issues for implementation of planned restoration measures Q3-Q4: Implementation	(Q1-Q2 Implementation)	
Restoration action: Assessment of results of physical restoration		Q2-Q3: Base-line assessment (regular forest inventory)	Q1-Q3 Assessment of "technical goals".	Q2-Q3: Follow-up assessment. (regular forest inventory)
Chronosequens monitoring	Q2-Q3 First round of monitoring (Malaise traps, Soil arthopods, Bioacoustics recording, Soil samples for carbon and remote sensing.	Q2-Q3: Malaise traps, Soil arthopods, Bioacoustics recording Regular forest inventory	Q2-Q3: Malaise traps, Soil arthopods, Bioacoustics recording Regular forest inventory	
Stakeholders	Q4: 2nd meeting with advisory board, feedback to reference-group after 1st stakeholder workshop, inkl draft of workplan. Development of communication plan.	Q1-Q4: Three meetings with advisory group, Continuous contact with different stakeholder groups. Activities included in communication plan. See also "Restoration activities" Q4: 2nd stakeholder workshop	Q1-Q4: Three meetings with advisory group, Continuous contact with different stakeholder groups. Activities included in communication plan. See also "Restoration activities"	Q1-Q4: Three meetings with advisory group, Continuous contact with different stakeholder groups. Activities included in communication plan. See also "Restoration activities" Q1: 3rd stakeholder workshop
Upscaling				

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8 Annex

8.1 Chronosequence

Table A1. The SE stand list sorted by series (pine and spruce) and stand age, and with stand numbers following the already established Krycklan plot numbering system. A selection of variables is presented (with all currently compiled variables presented in appendix).

Table 8.1 The SE stand list sorted of pine series and stand age, and with stand numbers following the already established Krycklan plot numbering system. A selection of variables is presented (with all currently compiled variables presented in appendix).

Plot #	SMC	Soil type	Longitude	Latitude	Elevation	Site fertility	Stand age	Volume biomass
74	Mesic	Podzol	19.8361305678882	64.2764833673083	263	4,8	23	57,8
89	Mesic	Podzol	19.8210746666872	64.2738457351092	255	3,0	30	24,4
485	Dry	Arenosol	19.8544545772	64.2160962852864	200	2,8	38	26,3
240	Mesic	Regosol	19.7453744511437	64.2542972237639	291	3,8	46	226,1
128	Dry	Podzol	19.8272448003879	64.2673139432564	254	2,6	50	95,7
500	Mesic	Podzol	19.8179195767543	64.2141420786752	209	4,5	50	143,9
464	Dry	Arenosol	19.8334075496728	64.2199018292128	164	4,4	55	105,2
475	Mesic	Regosol	19.7824996258955	64.2184529586108	253	3,3	64	144,3
78	Mesic	Regosol	19.7419039788134	64.2764096292536	323	4,1	71	171,9
48	Mesic	Podzol	19.7789781129562	64.2815555699952	284	4,1	73	84,1
53	Mesic	Podzol	19.8150179881626	64.2804017154866	272	3,6	73	151,6
175	Dry	Podzol	19.8333445179351	64.2609053092752	225	2,8	76	195,0
160	Dry	Podzol	19.7253756482388	64.2643886153187	311	4,1	77	213,0
329	Mesic	Cambrisol	19.8013444301854	64.2429878435955	209	4,2	80	263,1
384	Mesic	Arenosol	19.7708599680485	64.2345829904143	205	3,8	80	210,7
341	Mesic	Podzol	19.7360667464555	64.2420062967077	214	4,1	87	303,8
82	Dry	Podzol	19.7706794049109	64.2755596355259	314	4,0	90	163,2
295	Mesic	Podzol	19.73708178001	64.2482777465396	235	4,0	91	193,5
420	Mesic	Podzol	19.791385256921	64.2276091501012	201	4,0	94	329,0
217	Mesic	Regosol	19.7675358532747	64.2567210854949	273	4,0	121	301,4
245	Mesic	Podzol	19.7813759634536	64.2531094448621	274	3,9	141	256,6

347	Mesicmoist	Regosol	19.7791895444806	64.2405886037753	206	3,5	225	297,6

Table 8.2 The SE stand list sorted of Spurce series and stand age, and with stand numbers following the already established Krycklan plot numbering system. A selection of variables is presented (with all currently compiled variables presented in appendix).

Plot #	SMC	Soil type	Longitude	Latitude	Elevation	Site fertility	Stand age	Volume biomass
39	Mesic	Podzol	19.8443696510692	64.2825226065746	297	3,6	27	20,9
19	Mesic	Podzol	19.808920745886	64.2868280307026	284	4,1	50	172,6
187	Mesic	Podzol	19.7391891253321	64.2607827399087	321	3,8	64	177,4
354	Mesic	Regosol	19.8295427564924	64.2389540790609	180	3,9	75	173,3
378	Mesic	Podzol	19.8582314251015	64.234825492019	241	4,2	77	140,8
171	Mesicmoist	Podzol	19.804469308073	64.2617639329123	286	3,4	82	238,0
302	Mesicmoist	Regosol	19.7874241763957	64.246650025082	239	2,3	82	302,8
123	Mesic	Regosol	19.7913219491634	64.2685683896508	269	2,0	90	137,3
68	Mesic	Histosol	19.7929068233358	64.2779337491687	301	3,8	94	229,5
118	Mesic	Podzol	19.755101049997	64.2697283205577	302	3,7	95	160,3
292	Mesic	Gleysol	19.7155502348146	64.2489946192644	189	3,5	95	383,8
299	Mesic	Gleysol	19.7658990206142	64.2472998306685	258	2,6	140	256,7
468	Mesic	Podzol	19.862022884932	64.2190181854486	222	3,7	171	432,6
307	Mesic	Gleysol	19.8234287725794	64.2454548849079	200	3,6	172	110,7
248	Mesicmoist	Regosol	19.8030092524834	64.2523906948797	280	3,5	197	601,5

Notes: Elevation in m above sea level; Site fertility in m^3 per ha and year expected wood biomass production on average over a rotation period; Volume biomass for living trees

Note: Task 6.3 monitoring was not performed in stand 78 in 2022. Task 6.4 monitoring was not performed in stands 118 and 123 in 2022