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MASTER'S THESIS

Best practice for peatland restoration in Norway: the expert view

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Best practice for peatland restoration in Norway: the expert view

Master thesis in Climate Change Management

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Preface

I want to thank my interview participants Rune Halvorsen, Anders Lyngstad, Magni Olsen Kyrkjeeide, Pål Martin Eid, Suzanne Wien, and Erlend Skutberg for sitting down with me and providing with all the knowledge I needed. A special thanks to Pål Martin Eid, Suzanne Wien, and Liv Byrkjeland for taking me out in the field last summer, and Norway's environmental agency for funding my travel expenses and accommodation.

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Abstract

Peatlands play an important role in mitigating climate change in Norway, and provide many other ecosystem services. This puts pressure on the success of restoration efforts. The aim of this thesis was to synthesize knowledge on Norwegian peatland restoration and produce foundations for best practises in peatland restoration in Norway, and to compare Norwegian peatland restoration to the eight principles for ecological restoration by the Society of Ecological Restoration (SER).

To address this aim, I took a qualitative approach by interviewing restoration practitioners and scientific experts. Overall, the scientists were more critical regarding the older restoration projects, but developed a more positive outlook on the newer restoration projects. The practitioners were overall positive regarding the restoration success, but do see room for improvement. The interview results revealed five aspects in which peatland restoration in Norway can improve. Namely: goal setting, restoration methods, monitoring, climate change considerations, and organisation.

There is a need to reshape the national goals for peatland restoration in Norway, based upon the fifth principle by the SER. Statens naturoppsyn (SNO), the agency performing peatland restoration in Norway, needs to incorporate *Sphagnum* species revegetation practices in their restoration practices, to promote recovery and lower methane emissions. More monitoring data on the restoration success of peatlands is required to assess whether the national goals are being achieved. For this, monitoring actions need to scale up, separate monitoring projects need to merge or at least share their data, and monitoring should follow the Before-After-Control-Impact (BACI) design. While climate change will not force peatlands out of existence in Norway, it will affect certain areas negatively due to dryer conditions. Focussing restoration efforts on the areas most affected by climate change will have the biggest emission reduction effect. Norway's environmental agency should focus on composing a strategy on peatland restoration in areas that will become dryer due to climate change. It is at these sites that restoration will have the biggest impact.

Upscaling restoration efforts is needed to have significant impacts on the three national goals. To upscale restoration, SER principles one (stakeholder engagement) and seven (restoration gains cumulative value when applied at large scales) need to be better integrated.

Samandrag på norsk

Myr speler ei viktig rolle i utsleppsreduksjonar og karbonbinding i Norge og gir mange andre økosystemtenester som samla sett gjør det viktig å få til god restaurering av desse våtmarkssystema. Målet med denne masteroppgåva var å syntetisere kunnskap om norsk myrrestaurering og legge til rette for beste praksis ("best practise") i myrrestaureringa, og å samanlikne norsk myrrestaurering med dei åtte prinsippa for økologisk restaurering til Society of Ecological Restoration (SER). Eg brukte intervju med praktikarar i myrrestaurering og vitskapsfolk for å tilnærme meg denne målsetnaden.

Generelt sett var vitskapsfolk meir kritiske til eldre restaureringsprosjekt, men hadde fått ein meir positivt syn på nyare prosjekt. Praktikarane var positiv til restaureringssuksessen på dei fleste prosjekt. Resultata peiker på fem forbetringspunkt for norsk myrrestaurering. Det er eit stort behov for å forbetre nasjonale målsetnader basert på det femte prinsippet til SER. Statens naturoppsyn bør bruke meir revegetering i deira restaureringspraksis, spesielt bruk av *Sphagnum* på lokalitetar med bar torv for å sikre gjenoppretting og redusere metanustlepp. Meir overvakingsdata for restaureringsuksess trengst for å vurdere om nasjonale målsetnader blir oppnådd. Difor bør overvaking skalerast opp, ulike prosjekt må slås saman eller dele data, og overvaking bør følge eit før-etter-kontroll-effekt oppsett. Miljøendringar bør også takast meir omsyn til i myrrestaureringa. Miljødirektoratet burde vurdera å lage ein strategi for myrrestaurering som inkluderar at klima kan bli tørrare sidan dette kan ha stor påverknad på mange myrsystem. Oppskalering av restaureringsinnsatsen er essesielt for å kunne nå dei tre nasjonale måla. For å lukkast med oppskalering så må ein integrere SER-prinsipp 1 (deltaking), og 7 (restaurering får kumulativ verdi ved oppskalering).

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1 Introduction

Ecosystems all over the world are negatively impacted by human action, and as a consequence, ecological restoration to restore impaired ecosystems has emerged as a science of its own (Díaz et al., 2019). This has resulted in global treaties and commitments to preserve and restore nature. Restoration is currently receiving well-deserved recognition, with the United Nations General Assembly declaring 2021-2030 the "Decade on Ecosystem Restoration". This global recognition is much needed, as presently 75 percent of the Earth's land surface has been significantly degraded by humans. This number is even higher for wetland areas, of which 87 percent have been degraded due to human action (Díaz et al., 2019).

Peatlands are a type of wetland categorized by waterlogged soils, possessing a naturally accumulated peat layer (Joosten & Clarke, 2002; Lindsay, 2010). Due to the waterlogged soil, plant material does not decompose and their remains accumulate in situ, forming a waterlogged mass of organic material that is known as peat. Water is thus essential in the process of peat accumulation. Apart from waterlogged conditions, peatlands are also characterised by plant species that are well adapted to waterlogged soil conditions. In particular, *Sphagnum* mosses are well suited to tolerate permanent waterlogging and are also well suited to form peat (Thom et al., 2019). Peatlands can be classified in multiple ways, a mire is a peatland that supports a significant area of vegetation, which is normally peat-forming (Lindsay, 2010). Mires are subdivided into fens and bogs. Fens receive their water and nutrients from groundwater or moving surface water, and precipitation. Bogs receive their water and nutrients solely from precipitation (Thom et al., 2019). Peatlands provide many ecosystem services, such as regulating water quality and quantity, providing biodiversity, and storing and accumulating carbon, making peatlands important in both climate change adaptation and mitigation (Scharlemann et al., 2014).

Peatlands in Norway and Northern Europe emerged after the last glaciation, some 11,700 years ago, and have since then been accumulating and storing carbon (Loisel et al., 2017; Zak & McInnes, 2022). Nowadays, the total global carbon stored in peatlands is estimated to be 600 ± 100Gt (Kirpotin et al., 2021; Yu et al., 2021). To put this in context, 30% of all soil carbon is found in peatlands, while peatlands only take up 3% of the total land area (Scharlemann et al., 2014).

Peatland restoration focuses on reversing the hydrological changes made during initial land-use changes. When peatlands are drained, the peat is exposed to oxygen and starts to decompose, releasing carbon in the process (Harris et al., 2022). Due to the need for water peatland restoration should always focus on rewetting (Pakalne et al., 2021). Rewetting aims to re-establish peat and carbon accumulation, the core functions of a functional peatland ecosystem. Rewetting is achieved by damming and filling the ditches and other measures that stop the drainage which allows the water table to rise again. There is a wide range of methods for filling ditches and raising the water table. Apart from rewetting, there are additional measures for restoring, such as the reintroduction of peat-forming vegetation, or the removal of unwanted vegetation (Pakalne et al., 2021).

Currently, there is little data on assessing the restoration success of peatlands, due to a lack of monitoring across western Europe (Andersen et al., 2017). Zak and McInnes (2022) show the uncertainty and negative possible side effects of current inundation methods, such as high methane emissions and high nutrient mobilization. Thirdly, Kreyling et al. (2021) quantified restoration success by comparing rewetted fen peatland systems to near-natural peatland systems, with results showing no general trend towards natural conditions up to three decades after rewetting. These three studies highlight the uncertainty within peatland restoration, and that restoration success is in many cases, far away.

Norway is one of many countries investing time and money in restoring their degraded peatlands. In Norway, this has been the task of Statens Naturoppsyn/the Norwegian Nature Inspectorate (SNO), which falls under Miljødirektoratet (Norway's environmental agency). The restoration work started in 2016 (Miljødirektoratet, 2016), and got extended into 2021-present (Miljødirektoratet, 2020). The national goals for peatland restoration from Miljødirektoratet are to reduce greenhouse gas emissions; promote climate change adaptation, and improve ecological status in wetland areas (Miljødirektoratet, 2020). SNO started restoring peatlands in 2016, and has since worked on restoring around 80 peatlands, and other types of wetlands across the whole of Norway (Miljødirektoratet, 2020). SNO has been very productive in the field, which is demonstrated by their long list of restored peatlands, but in doing so SNO has produced almost no documentation on their procedures and methods. A lack of data on restoration procedures and success leaves many questions unanswered. Due to a lack of data, it is hard to say why restoration is successful, or unsuccessful, making it hard to learn from past experiences. Lacking data on SNO's methods and restoration projects also makes the continuity of future restoration fragile when current practitioners phase out.

To help further develop ecological restoration, the Society for Ecological Restoration (SER) developed eight principles of restoration that projects around the world can build upon (Gann et al., 2019). The principles were developed through consultation with professionals within the Society for Ecological Restoration and their peers in the global scientific and conservation communities. The SER developed the principles to be used by communities, industries, governments, educators, and land managers to improve ecological restoration practices across all sectors and in all ecosystems (Gann et al., 2019). The eight principles are to: 1) engage stakeholders, 2) draw on many types of knowledge, 3) be informed by native reference ecosystems while considering environmental change, 4) support ecosystem recovery processes, 5) be assessed against clear goals and objectives using measurable indicators, 6) to seek the highest level of recovery possible, 7) gain cumulative value when applied at large scales, and 8) be part of a continuum of restorative activities (Gann et al., 2019).

The aim of my thesis was to synthesize knowledge on Norwegian peatland restoration and produce foundations for best practises in peatland restoration in Norway, and to compare Norwegian peatland restoration to the eight principles for ecological restoration by the SER. To approach the aim of this study I structured my research question into five themes important for peatland restoration in Norway (table 1).

Table 1. The sub-questions used to address the main aim

Themes	**Sub-questions**
Goal setting	What are the practitioners', and scientists' views on the three national goals for peatland restoration in Norway, and are the goals sufficient in guiding restoration towards restoration success?

Restoration methods	What are the restoration methods for Norwegian peatland restoration, and can they be improved?
Monitoring	What is the state of current monitoring, how can monitoring improve, and are the national goals being achieved?
Climate change	What is the function of peatland restoration within climate change mitigation and adaptation in Norway and does climate change affect restoration?
Organisational aspects	What are the organisational difficulties for peatland restoration?

I addressed the main aim by conducting six interviews with both peatland restoration practitioners and scientists who are experts on the topic of peatland restoration to assess where peatland restoration stands in Norway and to guide future restoration projects.

2 Methods

I followed a qualitative approach consisting of six semi-structured interviews with three experts on peatland ecology, which I will call scientists, and three field practitioners from Norway. A qualitative research approach is applicable within restoration ecology when there is little literature, documentation or quantitative data available (Mohr et al., 2022). A qualitative approach is especially useful when, despite a lack of data urgent decisions need to be made on for example, the best restoration practices. In other words, there is little data concerning the success of peatland restoration in Norway, but there is a need to evaluate the restoration success of the last decade. This combination of urgency and uncertainty makes a qualitative approach a suitable approach (Moon et al., 2017).

I selected both scientists and field practitioners to understand the full scope of peatland restoration knowledge in Norway. The participants were selected by a purposeful sampling approach, meaning all participants were selected based on their expertise peatland restoration. All the practitioners restore in different regions of Norway, to capture possible differences within SNO. The three scientists have extended peatland ecology knowledge and represent different institutions that are active in peatland research. The interviews were conducted between February and March 2023 in the form of a video conference (using Microsoft Teams). The interviews were recorded and afterwards transcribed using Avrio 2022 software. The interview guide was the same for all participants, with some minor differences between the academics and practitioners (appendix). To the academics, I asked more specific questions regarding potential restoration methods, and to the practitioners, I asked more detailed about the current restoration methods. The semi-structured approach allowed for this flexibility while remaining organized. Each interview lasted for about one hour.

The data analysis followed a theoretical thematic analysis theory (Braun & Clarke, 2006). I followed a deductive approach based upon themes I recognized to be relevant to my research questions, and on the eight principles for ecological restoration by Gann et al. (2019). A thematic analysis is a method for identifying, reporting and analysing themes within data. I used a thematic analysis approach because it offers an accessible and theoretically flexible approach to analysing qualitative data while providing a detailed and complex account of the data (Braun & Clarke, 2006). Analysing themes within my data allows for clear and easy comparison between the six participants and their opinions, and specific methods, and understanding where the participants views overlap or differ. The themes were identified on a semantic level, meaning that I did not look for meaning beyond the responses of the participants.

Afterwards, I followed a progression from *description*, where my data were organized to show themes in semantic content, to *interpretation*, where I interpreted the content of the themes in light of previous literature. The data was categorized per theme, in relevant sub-themes, using Nvivo software. All responses by the participants that were coded into the sub-themes and were afterwards summarized and transformed into table format. Lastly, I analysed the summarized responses with relevant literature.

3 Results

The three scientists are Magni Olsen Kyrkjeeide, Anders Lyngstad, and Rune Halvorsen. Kyrkjeeide has a PhD in ecology, and is affiliated with the research institute NINA, her background is in biosystematics and peat mosses. At NINA she leads the team that monitors five peatland restoration projects from SNO, called the intensive monitoring program. Lyngstad has a PhD in plant ecology and has extensive knowledge on the restoration of many types of peatlands. After being employed for many years at NTNU, Lyngstad has recently moved to NINA. In association with Kyrkjeeide, Lyngstad is also involved with assessing and monitoring the results of hydrological restoration of peatlands. In 2018, Lyngstad led the expert group for wetlands in the work on the Norwegian Red list for habitat types, and he sat on the Scientific Council for Natur I Norge (Nature in Norway) from 2018–22. Halvorsen is a vegetation ecologist with a PhD in mire vegetation and has been responsible for the scientific content of Nature I Norge (Nature in Norway) for the last 17 years. Currently he is the head of the Geo-ecological research group at the Universitetet i Oslo (UiO) (University of Oslo).

The three practitioners are Suzanne Wien, Pål Martin Eid, and Erlend Skutberg. Wien´s educational background is in natural resource management and she has been working at the county governor´s office since 2012. There she has been working with peatland restoration since 2015. Eid´s educational background is in nature conservation and nature resource management. He has been working as a peatland restoration practitioner since 2009, and as a project leader since 2017. Skutberg has a background in nature management and GIS. In 2008 he started working at the Norwegian Nature Inspectorate (SNO), and the last four years he has been working with multiple types of nature restoration, including peatland restoration.

All participants expressed their views on the performance of SNO, with five out of six participants expressing mostly positive views. Halvorsen expressed the most negative views on SNO’s practice in peatland restoration. This view is based on his understanding of SNO’s restoration methods and having attended presentations of the first restoration projects, in which he saw damage from excavator machines, and a water table that was too high for *Sphagnum* species growth. As a solution, Halvorsen would like to see SNO reaching out to the scientific community in peatland ecology, to discuss the direction of future peatland restoration.

The other two scientists mentioned dissatisfaction with the earlier restoration projects but are more familiar with the newer restoration projects, in which they have observed an increase in restoration success. Kyrkjeeide mentioned that SNO holds practical knowledge on peatland restoration, which the academic world can also learn from. Lyngstad mentioned that the highest value lies not in the restoration projects, but in the team of practitioners SNO now holds. Norway did not have this before SNO started restoring and it is a good foundation for future restoration.

The practitioners were overall satisfied with the restoration results. Wien mentioned that within her region they have become good at preserving the old vegetation cover, which is a good substrate for *Sphagnum* species to grow on, during the restoration phase. According to her, the projects look good after restoration, and are ready to revegetate themselves with peatland vegetation. Eid expressed confidence in being on the right track for many of the restoration projects, due to learning from experience and comparing his restoration results to the results from restoration projects abroad, which according to Eid are reaching the same conclusions.

3.1 Goal setting

3.1.1 Opinions on national goals

The importance of adequate goal setting for peatland restoration was mentioned by three scientists and two practitioners (table 2). Four participants directly mentioned their view on the three national goals for wetland restoration, and all participants mentioned ways to improve the goals set by Miljødirektoratet. Between the four participants who expressed their opinion on the national goals, the overarching idea is that the goals need to be more targeted. Kyrkjeeide said it clearly, “*the goals set for restoration do not seem to be that clear. ‘Improve ecological conditions’, this has to be defined in a way”* (M.O. Kyrkjeeide, personal communication, February 21, 2023).

Kyrkjeeide also mentioned a deviation between what SNO is trying to achieve and the national goals. In reality SNO practitioners are trying to return *Sphagnum* species cover, and this is also what SNO monitors. While *Sphagnum* species cover can be a proxy for national goal achievement, SNO does not directly measure if they are achieving their three goals. This ties into what Wien mentioned about the goals. Wien expressed that currently there is no way to monitor if restoration is reaching the national goals (table 2). This is mostly a consequence of limited monitoring schemes, but, according to Kyrkjeeide, also because the goals are not measurable.

3.1.2 Suggestions for goal improvement

The participants proposed several strategies for improving the national goals, with similar strategies being proposed by the scientists and practitioners. Within Kyrkjeeide's own research project, the goal is to facilitate *Sphagnum* species recovery as fast as possible and to see if revegetation actions help recovery (table 2). The underlying idea behind this is that *Sphagnum* species cover is essential for peatland restoration success. This is in agreement with Halvorsen´s view, who mentioned the need for *Sphagnum* species establishment to achieve peat accumulation, which is the most important goal according to Halvorsen:

"There is one goal and that is to restore peat accumulation... That is the one and only goal, I think. This is because that also encompasses all the other ambitions of peatland restoration. Peatland ecosystems are characterized by peat accumulation and if you do not manage to restore peat accumulation then you have failed quite simply" (R. Halvorsen, personal communication, February 16, 2023).

Lyngstad mentioned a need for targeting the national goals based upon nature types and representativity of the restored peatlands (table 2). This means prioritising restoration of peatland types that are relatively rare in Norway. While fens are rarer, Lyngstad proposed to focus on raised bogs, because they are often in a worse state than fens due to residing in lower lying areas. Focusing on representativeness of mires means that restoration should also mirror the different peatland systems Norway has. Peatlands in western Norway are similar to Scottish ones, while peatlands in the eastern part are similar to Swedish peatlands. Restoration should focus on preserving the whole range of Norwegian peatland systems.

Wien would like to add monitoring schemes that enable assessing whether the national goal is being achieved. Eid referred to international standards and principles from the Society for Ecological restoration (Gann et al., 2019) and the United Nations (FAO & SER, 2021), to be used as a foundation for the national goals. Since most of the restoration work is done in protected areas, Skutberg thinks goals should be guided by the conservation value of the area (table 2).

Table 2. Synthesis of responses related to goal setting in peatland restoration in Norway

Participants	Opinions on national goals	Suggestions for goal improvement
Kyrkjeeide	• Goals are too general.	• Quick *Sphagnum* species revegetation
Halvorsen		• Restoring peat accumulation. • Restoring towards pristine.
Lyngstad	• Goals are not targeted.	• Prioritize within nature types. • Focus on representativity of peatlands.
Wien	• No ways to measure goal achievement.	• Monitoring to see if national goals are achieved.
Eid	• Goals are sufficient but miss international standards.	• Add international standards in Norwegian restoration (Society for Ecological Restoration & United Nations principles).
Skutberg		• Restoring degraded nature and its conservation purpose. • Work reflects conservation value.

3.2 Monitoring and goal achievement

3.2.1 Knowledge of current monitoring

SNO performs standard monitoring on all their restoration projects, which includes one or more vegetation group transect per site (table 3). These transects are set before restoration and sampled the first year after restoration and then every third year. SNO does not evaluate hydrological aspects and wildlife, apart from visually inspecting the water level and wildlife, in particular birds.

Relative to the restoration efforts, the monitoring projects are at small scale, and there appears to be little cooperation between the monitoring projects. These monitoring programs include the standard monitoring by SNO, an intensive monitoring program involving Kyrkjeeide and Lyngstad, a *Sphagnum* species revegetation monitoring project by Kyrkjeeide, a greenhouse gas emissions project, and a hydrological monitoring project (table 3). However, across these projects there has been little communication.

The intensive monitoring project involving Lyngstad and Kyrkjeeide is an ongoing project run by NINA, which includes five sites for which they took drone photos, collected data on mire structures, vegetation group analyses along transects, and species composition along transects for monitoring purposes (table 3). According to Kyrkjeeide and Lyngstad this methodology for monitoring worked, apart from the drone photos, which were hard to connect to the ground data.

In Norway, there is one greenhouse gas emission monitoring project, and there are four hydrological monitoring projects (table 3). These monitoring efforts are not connected to the other monitoring projects from NINA and according to Kyrkjeeide there is no communication between the project groups.

3.2.2 Best practice for monitoring

According to the participants, monitoring needs to both scale up, and change its methods (table 3). Many participants favour vegetation plots over transects; according to Kyrkjeeide vegetation plots are also easier to connect to drone photos than transects. Most participants also mentioned the need include both hydrological and vegetation monitoring. Hydrology and vegetation are strongly linked together in peatlands and there is a need to understand how they correspond after restoration. Lyngstad mentioned monitoring via the Before-After-

Control-Impact (BACI), which includes monitoring before and after restoration, and at a control site. This design allows the restoration intervention effects to be separated from any other impact. While other participants did not mention the BACI design directly, Wien and Eid did explain the same principles for monitoring (table 3). Like other participants, Lyngstad also mentioned favouring plots over transects. As other national monitoring programs (ANO) use plots for monitoring this would create more comparable data sets (Tingstad et al., 2019).

3.2.3 Goal achievement

As there is currently not enough data to assess restoration success, according to Kyrkjeeide assessment is currently dependent on visual inspection. Most of the participants agreed the restoration projects are heading in the right direction and mentioned seeing a strong learning curve within SNO. On visual inspection the vegetation and hydrology in many restoration sites seem to be moving towards pristine conditions, meaning that *Sphagnum* species are returning, and the water table is rising to original levels. The visual inspection corresponds with the Kyrkjeeide's first data that that are now being analysed, but according to Kyrkjeeide the data are not conclusive. In restored areas that were heavily degraded, current methods were not successful in reaching the national goals according to Lyngstad and Kyrkjeeide. According to them, restoration is most successful in flat areas with deep peat (table 3).

Halvorsen stated that he had not visited the restoration sites and would refrain from making premature conclusions until research is published. However, he expressed scepticism regarding the effectiveness of current methods in achieving peat accumulation. He ascribes this to the use of heavy excavators damaging the soft peat, and high water levels after restoration in which *Sphagnum* species do not establish (table 3).

Table 3. Synthesis of responses to questions related to monitoring in peatland restoration in Norway, scientist in grey, practitioners in white

Participants	Knowledge of current monitoring	Best practice for monitoring	Goal achievement
Kyrkjeeide	• Experiments on *Sphagnum* species reestablishment • Five intensive monitoring sites	• Usable drone photos. • Vegetation plot monitoring • Connect hydrological, vegetation, and GHG exchange • Monitor all used methods	• Clearer goal setting required to assess goal achievement • Data might suggest recovery towards reference • No success in heavily damaged sites • SNO has gained much experience the past years
Halvorsen		• Important to evaluate restoration success • Important to know specifics per site	• Reluctant that current methods are achieving peat accumulation
Lyngstad	• Five intensive monitoring sites • Hydrology monitoring is separate	• BACI design • Vegetation plots (ANO) • Aerial photos • Focus on representativeness of mires • Species level monitoring with complex questions • Group level monitoring with simple questions	• In flat areas with deep peat current methods work • Intensive monitoring successful, apart from drone photos
Wien	• One GHG exchange monitoring site • Transect vegetation group monitoring at all sites	• Hydrology before and after • More GHG exchange monitoring • Vegetation plots • Peat depth • Peat dam longevity	• Monitoring insufficient to assess national goals • Positive change in both hydrology and vegetation

Eid	• One or more vegetation group transect per site • Four hydrological measurements sites • Vegetation used as proxy for water table	• Hydrological and vegetation measurements before and after at restoration site and reference site • Model hydrological data to predict hydrology other mires • Monitor water chemistry before and after • Monitor every fifth year • Monitor peatland swelling	• Successful in a broad sense • Water table rises to pristine levels
Skutberg	• Monitor: birds, vegetation transects, and visually check water level and peat dams.		• Projects from five years ago are looking good

3.3 Restoration methods and potential improvements

3.3.1 Current SNO restoration methods

Current SNO restoration methods are mostly based upon hydrological restoration, that try to raise the water table to pristine levels. This is done by closing and damming the ditches that drained the peatland system. The principles for this are the same within SNO and include the filling of ditches, removing unwanted vegetation (trees), and raising the water table, but there are differences within the execution of these steps. Wien used unoxidized peat for the peat dams, and oxidized peat, found on ridges alongside the ditch, as filling for the remainder of the ditch. Unoxidized peat has not been exposed to oxygen and has thus not degraded. Eid used unoxidized peat for both the dams and for the filling of the ditch, believing this mimics the pristine water speed in the peatland to a greater degree, because degraded, oxidized peat does not have the same water holding capabilities as unoxidized peat. The unoxidized peat is taken from within the same peatland. The excavator folds back the vegetation layer, extracts the unoxidized peat used for dam construction, and with Eid's approach to fill ditches, fills the hole with branches, trees, etc. and folds back the vegetation layer (table 4).

In fen restoration a lack of peat to build dams with can be an issue, because the peat is often too shallow. Eid and Skutberg used wood to construct dams for fen restoration. Eid mentioned that filling the ditches in fens is even more important than in bogs. The ditches are still filled with material from the side, and according to Eid the ditches are well able to restore the hydrology, even in materials like sand and dirt. In some cases, machines are used to cut away grasses. In these cases it is important to keep a smooth surface on the fen after restoring (table 4). Excavators are the standard tools for most peatland restoration projects but are not always used during fen restoration. Fen ecosystems are often deemed too vulnerable for the use of excavators due to high amounts of rare species according to Skutberg. In bogs, the excavators drive on big logs or spring mats (rubber mats) to distribute the pressure on the soft peat (table 4).

While the restoration methods are aimed at restoring the hydrology of the peatland, in later years there is a strong focus developed on keeping the old surface vegetation to avoid bare peat (table 4). This vegetation established after ditching because it is better suited for the dryer conditions. While these are no peatland vegetation species, according to the SNO practitioners, the *Sphagnum* species growth response on this vegetation is better than on bare peat.

3.3.2 Potential restoration methods

The scientists Kyrkjeeide, Halvorsen, and Lyngstad all had suggestions to improve current restoration methods. Halvorsen addressed the need to improve current restoration methods by following specific restoration plans per peatland site based on the hydromorphological type, and by working manually to prevent excavator damage. Kyrkjeeide and Lyngstad mentioned the need to combine current hydrological restoration with ecological restoration. Kyrkjeeide mentioned doing so by active revegetation of *Sphagnum* species fragments. Kyrkjeeide advised to find out where peatland vegetation is not re-establishing, and to introduce revegetation measures at such locations (table 4):

"when you restore them, I think that could be a good thing to get the mires back as they are supposed to be. But then you need to add ecological restoration to actually improve them and make sure they're mires, so they are not left there open, like just completely open with bare peat. I have no idea how long time it'll take to, re-vegetate that in the natural process, which is done in other kind of soil types. But for mires, that's, I don't think that works very well. So then you need to add these ecological restoration parts with active revegetation" (M.O. Kyrkjeeide, personal communication, February 21, 2023).

Currently most of the peatlands restored by SNO are in a similar state of degradation according to Kyrkjeeide. The peatlands are drained with ditches and non-peatland vegetation has taken over, but vegetation wise they are still relatively open, meaning that dense forest did not establish. Peatlands in Norway were drained for two reasons, forestry and agriculture. The peatlands drained for agriculture did not become protected nature areas, but some of the peatlands restored for forestry were taken up in protected nature areas. Since SNO is mostly restoring in protected nature areas, they have mostly restored afforested areas. When SNO wants to expand their efforts outside of protected nature areas they will encounter privately owned forest areas, and agricultural lands that were formerly peatlands. According to Kyrkjeeide, peatlands that were turned into agricultural areas are much more degraded than forested peatlands, meaning that current restoration methods may not work. In response to a question about the Topsoil Removal method, she mentioned that this approach could be applicable for agricultural land (table 4).

Knowledge about the different hydromorphological peatland types is important when making specific plans per restoration site according to Halvorsen. The practitioner needs to understand where the water came from and how far the drainage has reached, and in some cases restoration is no longer possible. Lyngstad was in agreement with this, not all degraded peatlands have restoration potential. Knowledge about peatland ecology is the foundation for this assessment according to Halvorsen, after which specific plans can be made per site to resume peat accumulation (table 4).

Kyrkjeeide thought the principles for bog and fen restoration to be the same: restore the water table level, and remove trees, bushes, and other unwanted vegetation. Kyrkjeeide stated the biggest difference between fens and bogs to be after restoration. Rich fens overgrow quickly after hydrology changes, and this vegetation outcompetes target vegetation. She advised on actions to remove unwanted vegetation after restoration (table 4). In contrast, according to Halvorsen fen and bog restoration are two very different processes.

"They are ecologically completely different systems. Their water comes from different sources, and so on, and all of peatland restoration is about water because, water and storage of water is the basis for production of peat. So of course, you have to take into account where the water comes from, how much water you want to store in the peatland. To let in too little and too much, I think both will be bad for the goal achievement, when it comes to restoring peat accumulation. So yeah, you have to think very differently" (R. Halvorsen, personal communication, February 16, 2023).

Another disagreement among Halvorsen, and Kyrkjeeide and Lyngstad is on the use of excavators. According to Halvorsen they damage the peat, as it is too soft a surface to drive on (table 4), while Kyrkjeeide and Lyngstad believed SNO's methods for reducing excavator damage to be sufficient in most cases.

SNO practitioners Wien and Eid also proposed improvements concerning restoration methods. Wien agreed with Kyrkjeeide and Lyngstad on including more ecological restoration in addition to hydrological restoration (table 4). While Eid mentioned the potential of cooperating with parties outside of Norway to find commonalities and knowledge gaps.

Table 4. Synthesis of responses to questions related to restoration methods in peatland restoration in Norway

Participants	Current SNO restoration methods	Potential restoration methods
Kyrkjeeide	• Preserve old vegetation cover • Good excavator standards	• Include ecological restoration by revegetation *Sphagnum* species • Fens overgrow quickly, keep vegetation open • For agricultural restoration topsoil removal method
Halvorsen	• Negative towards excavator use	• Restoration work manual • Hydromorphological types need consideration • Specific plans per mire • Fens and bogs require different methods
Lyngstad	• Preserve old vegetation cover	• Sometimes ecological restoration is needed, sometimes hydrological restoration, sometimes both • Sometimes restoration is not required • Avoid bare peat phase, get *Sphagnum* species cover quickly • Restored fens can grow *Phragmites australis*, overshadowing other species
Wien	• Unoxidized peat only for peat dams • Preserve old vegetation cover over the whole site • Fold back the vegetation in the ditch, fill the ditch with side material, and fold the vegetation back onto the ditch • Dam for every 40 centimetres fall, or max 30 meters • For dams, dig to find unoxidized peat, fill the hole with rest material and fold the vegetation back.	• Optimize the water speed • Combine ecological and hydrological restoration

Eid	• Ideal water level a few centimetres under the vegetation • After restoration the mire looks to wet, but the mire swells up • Adapt methods depended on area but main goals are the same (raise the water table, block the ditches) • Restore in such a way that no extra actions are needed • Fill the ditches completely with unoxidized peat • Take the peat from holes on the side, fill the hole with rest material and put the vegetation back on top. • For fens use wooden dams	• Learn more from other countries doing mire restoration • Overview needed of existing knowledge and then find out if there are gaps
Skutberg	• Restoration actions depend on the state of the peatland • Hydrology is the main focus, keeping old vegetation is gaining importance • Work slow and have good contractors (entrepreneurs) • Wooden dams for rich fens and harvested fens, work manually • Guide excavators (contractors) in the beginning • Use spring mats when driving excavators	

3.4 Climate change

3.4.1 Climate change mitigation and adaptation function

The value of peatland restoration concerning climate change mitigation and adaptation varied among the participants. Some of the participants did not ascribe a high value to peatland restoration for climate change management due to the relatively small scale of restoration projects. All participants mentioned the need for more protection of peatland areas, and upscaling restoration efforts to achieve a higher climate change mitigation effect (table 5).

Relative to the other participants, Lyngstad ascribed the highest climate change mitigation value to peatland restoration, mentioning that peatland restoration is very important in climate change mitigation in Norway. This is due to the high current emissions from drained peatlands. Lyngstad mentioned a project he worked on which calculated emissions from drained peatlands in Norway. These emissions are not included in Norway’s reported annual emissions, increasing the importance of peatland restoration to stop these emissions (table 5).

“It's difficult to get a very accurate estimate because we don't know how much mire we have. We don't know the area. We don't know the area that's drained. We don't know the area that's been turned into agricultural fields, exactly. And we don't know how much peat is left in those areas. And we don't know the turnover of peat and the exact contribution to GHG emissions from each area unit. So there are lots of unknowns there. But from what we know in general, if you use the IPCC emission factors, for instance, that are worked out based on data from other countries, then that's roughly where we are, 10% to 20% of the Norwegian emissions” (A. Lyngstad, personal communication, March 2, 2023).

Most of the participants agreed that restoration needs to scale up to have a significant climate change adaptation function. They did acknowledge that current restoration provides a small climate change adaptation function, for example by providing flood protection, or water storage. However, according to the participants, with today’s efforts the impact of peatland restoration remains small, as the restored areas are small (table 5).

“I think, we have to realize that the amount in terms of percentage of the total land area, that will be restored is not going to be extremely high. We have to be realistic in this

regardless of how much money and effort we put into this, I think it's hardly going to help in preventing floods in large rivers or things like that. But of course, if there are small catchments with flooding large problems, then it might help a little bit. The answer to the question is that this will be context dependent and, it has to be judged with realism" (R. Halvorsen, personal communication, February 16, 2023).

3.4.2 Climate change effects on peatlands

According to the participants, climate change will have an impact on peatland systems in Norway. They mentioned a gradient on how the climate in Norway will change, which will affect how the peatlands are impacted. Two scenarios were proposed: warmer and dryer, which would result in peatland degradation, Due to the dryer conditions there would be less *Sphagnum* growth, and secondly warmer and wetter, which would result in higher production and thus peatland growth. Lyngstad expects the south-eastern part of Norway to become warmer and dryer, while he expects the northern and western parts to become warmer and wetter (table 5). He advised focusing restoration efforts on the warmer and dryer areas, as he expects peatlands in the warmer and wetter areas to be less vulnerable to ditching.

Currently, climate change is not taken into account in the site selection process, but it is accounted for within the restoration process itself. Eid mentioned that restoration methods are very important when considering the effects climate change will have on some peatland systems (table 5). For peatlands experiencing a higher frequency of drought, keeping the water in as long as possible is key. The slower the water speed, the more drought resistant the peatland. Eid gave this as a reason why it is important to fill ditches completely with unoxidized peat, as this mimics the original water speed to the greatest degree. Wien agreed that restoration increases the climate change resilience of disturbed peatlands (table 5). The combination of higher precipitation and ditching results in more erosion and thus peat degradation, which can be mitigated by restoration.

3.4.3 Climate change risks of peatland restoration

The participants did mention a caveat: methane. There are climate change risks related to restoration itself. Due to increased methane emissions upon rewetting, restoration success becomes more important because when restoration fails, the net-emissions might be higher due to methane emissions. A quick *Sphagnum* species growth response is important in mitigating methane emissions, as it contains methanotrophs metabolising the methane, according to Lyngstad, and Kyrkjeeide (table 5). It was also mentioned that restoration methods play a role in mitigating methane release. Especially in fens, vascular plants establish quickly after rewetting and can pump out methane. The participants mentioned the importance of cutting or mowing of these plants after restoration, Eid mentioned that SNO already includes such management measures in some cases. Active revegetation can be another method to speed up *Sphagnum* species establishment and lower methane emissions according to Kyrkjeeide (table 5).

Table 5. Synthesis of expert views on climate change (CC) related issues in peatland restoration in Norway				
Participants	**Mitigation function**	**adaptation function**	**CC effects on peatlands**	**CC risks of restoring**
Kyrkjeeide	• Leaving intact mires intact most important • Restoration, not an argument to destroy intact peatlands	• All projects have a local adaptation function	• Drought reduces primary production and increases degradation • Warmer and wetter conditions increase primary production • Strategize which peatlands to restore • Restoration keeps water in peatland systems during droughts	• When the goal is to keep carbon in the ground, keep methane emissions low • *Sphagnum* species reduce methane emissions • Rewetting (without revegetation) and vascular plants pumping out methane is not mitigation
Halvorsen	• Peat accumulation is the most important ecosystem service	• Mitigation more important than adaptation • Restoration areas are too small-scale for adaptation functions	• Higher precipitation and temperatures will impact peatlands • Future weather balance is uncertain, thus hard to predict the effects • Norwegian peatlands are relatively safe from the effects of climate change	• There is methane release upon rewetting in the first phase of restoration • It is more important that restoration can restart peat accumulation

Lyngstad	• Emissions from drained peatlands are circa 10% of total emissions in Norway • We do not know the total peatland area in Norway		• Depends on the balance between temperatures and precipitation • With temperature and precipitation increase, peat accumulation • Temperature rise without precipitation rise is degradation instead • Eastern to south-eastern part will be dryer and might see peat degradation • Restoration should focus on areas more vulnerable to climate change	• Avoid the bare peat phase • *Sphagnum* species have methanotrophs living in them, reducing methane emissions • Fens have high biomass production after restoration, resulting in grasses (*Phragmites australis*) overshadowing other species and emitting methane
Wien	• Restoration scale is small, but overall there might be mitigation effects	• Restoration has a positive effect on adaptation functions	• Bogs are more exposed to climatic changes than fens • Higher precipitation results in more erosion in ditched peatlands • Restoration helps against climate change effects on peatlands	• Methane release upon rewetting • Keep the water table as low as possible, but high enough for *Sphagnum* species growth
Eid			• Restoration methods are important concerning climate change effects • Keep water in as long as possible during dry periods • Unoxidized peat keeps water better • Currently restoration does not take climate change into account in site selection	

Skutberg	• To stop further degrading and prevent GHG emissions • The work is too small-scale for meaningful impact • Stop destroying intact peatlands	• To small-scale for adaptation effects, upscaling needed • Maybe in the future we see that flooding costs are higher than restoration costs

3.5 Organisational aspects and stakeholder involvement

Organisation appeared as an important theme and as an obstacle to Norwegian peatland restoration. The subthemes that appeared through the interviews were decision making structure, stakeholder involvement and importance, upscaling restoration, and the various challenges in peatland restoration in Norway.

3.5.1 Decision making structure

Within the decision-making structure, it appeared that restoration was not limited by funding, but rather by legality (table 6). Wien mentioned that she selects potential sites within her area to then apply for funding, and that funding always has been provided. Currently, restoration is mostly in protected nature areas. The scientists and field practitioners mentioned that SNO needs more rights to restore (unproductive) agricultural land. Halvorsen is convinced that SNO has been operating too much on their own, and wanted better knowledge integration from the scientific community in SNO. He welcomed a debate between experts and SNO to decide on the future of peatland restoration (table 6).

3.5.2 Stakeholder involvement and importance

Perceived stakeholder importance ranged among respondents from having some value to being essential. Arguments for the relatively low assigned value are that peatland restoration itself is too complex for high stakeholder involvement, and the role of stakeholder involvement in peatland restoration is limited to lowering anxiety and creating enthusiasm for the project (table 6). Other participants assigned a much higher value to stakeholder importance, especially to the role of local residents. According to Eid, a higher awareness on the local level is absolutely necessary to upscale restoration (table 6). Without involved stakeholders and an aware community, there will be too many obstacles to scale up restoration efforts. Currently, stakeholder involvement is limited, while practitioners try to get local media coverage, hang up posters around project sites to spread awareness, and talk to all landowners involved, the practitioners believed more stakeholder involvement is needed. All practitioners mentioned the need for more stakeholder involvement, with Eid mentioning this should be based on Gann et al. (2019) and FAO and SER (2021) (table 6).

3.5.3 Upscaling restoration

All participants mentioned a need for upscaling restoration efforts. The argument for this is a climatic one; without serious upscaling efforts climate change mitigation and adaptation functions will not be realized. Currently upscaling faces many obstacles, including legal difficulties to restore outside of protected nature areas, lacking personnel to restore, and limited stakeholder involvement. All participants proposed measures to upscale restoration and proposed more education, knowledge cooperation and spreading to help upscale restoration. SNO has to start spreading what they have learned about peatland restoration during the last 8 years to new practitioners, and the scientific community. It is also important to include peatland ecology expertise in Norway in current restoration practice (table 6).

3.5.4 Challenges in Norway

All participants mentioned the discrepancy between the total restored area and the total destroyed area (table 6). The participants mentioned that too many peatlands are still being destroyed by developers. This came with the fear among participants that restoration can be used to legitimize the degradation of intact peatlands.

Kyrkjeeide, Wien, and Eid expressed that they want to see peatland restoration gain legal rights to restore outside of protected nature areas, as it is currently very difficult to restore peatlands that are being used for agriculture (table 6). None of the participants addressed the need for more funding. While more funding could be needed when restoration starts upscaling, none of the participants believes funding is currently the reason why restoration has not been upscaled yet.

Other challenges that limit peatland restoration in Norway are a lack of capable personnel and a lack of records on where the ditched peatlands are. A lack of personnel is currently the biggest challenge according to Lyngstad and Skutberg (table 6). All participants mentioned the need for upscaling restoration efforts, but this is impossible without more field practitioners. It takes time to find potential restoration sites, putting more pressure on the already understaffed practitioners, and it makes it difficult to compose a restoration strategy according to Wien (table 6).

Table 6. Synthesis of responses to questions related to organisation and stakeholder involvement in peatland restoration in Norway

Participants	Decision making structure	Stakeholder involvement & importance	Upscaling restoration	Challenges in Norway
Kyrkjeeide	• Restoration dependent on legality		• Limited legal rights outside of protected nature	• Development projects are looking into moving mires • Clearer goals, and more monitoring to know where to apply extra measures • Better exchange between groups • Legality challenges
Halvorsen	• SNO operates too much on their own • SNO should invite scientists for an open discussion	• Information is important to reduce anxiety, scepticism and create enthusiasm • Peatland restoration is too complex for direct involvement	• Knowledge and knowledge cooperation needed • Raise awareness among all nature management sectors	• Include existing knowledge better • Avoid greenwashing restoration, to further destroy intact nature • More actions to protect nature
Lyngstad		• Good stakeholder involvement is essential	• Restoration should be integrated into other/national plans	• The lack of manpower and expertise to restore well • Overview of ditched peatlands needed • Stakeholder involvement, and landowner consent needed

Wien	• Applications are sent to the Miljødirektoratet by practitioners • Surrounding regions cannot affect the peatland, and vice versa	• Informing with posters • Inform landowners within the nature reserve restored in • Media coverage • More outreach needed	• More offensive towards agriculture • More conflict when trying to restore bigger areas • Difficult to spread the information SNO has gathered	• No record on ditched peatlands • Not enough active practitioners and practitioners are confined to one area • Practitioners are competing amongst themselves for entrepreneurs • Restoration should not be used to legitimize destroying intact nature •Results in upscaling difficulties
Eid	• SNO works in protected nature areas • Miljødirektoratet measures success by how many ditches are closed, this restricts • There is no influence on the landscape scale but needed • Stronger focus on protection compared to restoration	• Raise awareness of peatland benefits • Stakeholder involvement is necessary to upscale restoration • Adapt international standards and principles, which include more stakeholder involvement (United Nations principles, SER)	• Educate people in restoration • Norway needs many types of nature restoration • Gather all information in Norway and other countries	• Most of the peatlands are outside protected nature areas • Incorporate restoration knowledge from other countries

Skutberg	• County governor selects restoration sites • Field practitioners do the planning, and the county governor contracts the entrepreneurs • Entrepreneurs have a fixed price, an hourly rate is better	• Communication with landowners essential	• Upscaling needed to have climate change impact • More practitioners needed • There are enough entrepreneurs to scale up	• More nature is destroyed than restored • The bottleneck is the lack of practitioners

4 Discussion

The aim of this thesis was to synthesize knowledge and make fundaments for best practices in peatland restoration in Norway and compare Norwegian peatland restoration to the eight principles for ecological restoration by the SER (Gann et al., 2019), based upon interviews with three scientists and three practitioners. Overall, I found that there is a need to make the national goals more targeted, include more ecological restoration practices like *Sphagnum* species revegetation, take the consequences of climate change into account when strategizing where to restore, and the need to upscale restoration practices.

4.1 What are the practitioners' and scientists' experts views on the national goals for peatland restoration in Norway, and are the goals sufficient in guiding restoration towards success?

The participants proposed to improve the national goals by making them more targeted and by relating them to international standards and principles. The lack of targeted and measurable goals is currently affecting the restoration practice. For example, composing a good monitoring program is hard without a targeted goal. Similarly, the restoration methods reflect the overall goal, and without a targeted goal the restoration methods will thus not be targeted either (Gann et al., 2019). The literature on goal setting for ecological restoration is aligned with the need for more targeted goals that I found in my study. The fifth principle for ecological restoration (Gann et al., 2019) states that ecosystem recovery should be assessed against clear goals and objectives, using measurable indicators. Currently, the three national goals from the environmental agency do not fit this description, as they are not measurable, do not include objectives, and thus lack a time component. Objectives are a statement of the interim outcomes along the recovery process, and do thus provide a time component to the goal setting. To transform the national goals to fit the description by the SER they should include a medium to long-term desired ecological condition, with the level of recovery sought, and the goals should be assessed against objectives. Objectives are valuable in assessing recovery after restoration, because peatlands take a long time to fully restore (Kreyling et al., 2021). Assessing their restoration success along their restoration trajectory would provide oversight in the interim restoration success. This is supported by Zedler and Callaway (1999), who state that having a prediction of time to recovery aids guiding the restoration process, and by Rydgren et al. (2020); Rydgren et al. (2019), who´s results support the view that ecological restoration should develop methods to predict time to recovery. A prediction of time to recovery is especially valuable in harsh environments, like in Norway, where restoration often takes longer compared to more temperate environments (Rydgren et al., 2011).

Lyngstad mentioned the need to focus on representativeness of Norwegian peatlands to make sure that the whole gradient of peatland types in Norway gets restored. Currently, Lyngstad's need is not reflected in the national goals, because the goals do not mention peatland types. This means there is no focus on the representativity of Norwegian peatlands. If Norway wants to preserve their variation in peatland systems, the representativity needs to be included in the national goal setting. The first two national goals; to reduce greenhouse gas emissions, and to promote climate adaptation, are especially based upon the ecosystem services of peatlands – processes or functions of an ecosystem that provide benefits and value to people (Bullock et al., 2011; Suding, 2011). There are possible downsides to this ecosystem-services' way of thinking. When restoring for ecosystem services, services that provide something for society are valued more than aspects of ecosystems that do not directly serve our society (Kosoy & Corbera, 2010). When the goal setting focuses on climate change mitigation and adaptation, the representativeness of Norwegian peatland systems might get overlooked, as these two goals would focus on larger peatland systems that optimize climate mitigation and adaption impact. This is not an argument to abandon the climate change mitigation and adaptation focus. Lyngstad himself stated the importance of mitigating the current emissions from drained peatlands. It only states the need to not overlook aspects of Norwegian peatlands that do not directly benefit human society.

4.2 What are the restoration methods for Norwegian peatland restoration, and can they be improved?

Practitioners differ in their methods for hydrological restoration, especially in what material to use for dams to create optimal water speed and how to re-establish *Sphagnum* species. According to the peatland restoration handbook (Schumann & Joosten, 2008), the main challenge for restoring hydrology is to store enough water during wet periods to prevent drought during periods of water shortage. Because Eid used unoxidized peat for the whole ditch, his method might hold water better in preparation for dry periods. Schumann and Joosten (2008) mentioned the need to consider the location of the peat extraction site to keep additional damages low, and that oxidized peat still has sealing properties and supports vegetation growth that supports stabilisation. According to Schumann and Joosten (2008), both methods are sufficient for raising the water table but have different qualities. Rather than choosing one over the other, SNO could use them strategically. For example, for drained peatlands that often face dry periods, SNO could use unoxidized peat for filling ditches, and for drained peatlands that are too vulnerable to additional damages due to peat extraction, SNO could use oxidized peat.

Although current restoration methods focus strongly on hydrological restoration, Kyrkjeeide, Wien and Lyngstad expressed the need to include ecological restoration as well. This would include revegetation with *Sphagnum* fragments to help with a quick revegetation response and active management of unwanted vascular plants. A quick *Sphagnum* species cover would lower methane emissions and accelerate the peat accumulation process.

Kyrkjeeide advised to find out which restored sites still have much bare peat and to revegetate these sites using *Sphagnum* species fragments. This is in line with Pakalne et al. (2021), who stated that when the target species do not establish after hydrological restoration, reintroduction can be considered. This is often the case in peatlands with much bare peat, which can be present in peat extraction areas (Järveoja et al., 2016), and can also occur when the vegetation layer got degraded by restoration. In these cases, hydrological restoration is often not enough to re-establish peatland vegetation, and additional revegetation measures are required (Järveoja et al., 2016). Järveoja et al. (2016), suggest that a combination of rewetting and revegetation with *Sphagnum* mosses can serve as an effective method to mitigate the negative climate impacts of abandoned peat extraction areas. Similar restoration methods have been used in other countries. In northern Estonia a study evaluated the response of moss layer transfer techniques (revegetation with *Sphagnum* species) on the above biomass (Purre et al., 2020). Their results showed that revegetation hummock *Sphagnum* species (*Sphagnum fuscum* or *Sphagnum rubellum*) led to the greatest increase in *Sphagnum* biomass, which indicates the greatest restoration success (Purre et al., 2020). Until there is more specific Norwegian documentation available, revegetation with hummock *Sphagnum* species is probably the best way forward.

Another argument for revegetation with *Sphagnum* fragments is methane emissions upon rewetting of the degraded peatland site. Methane emissions occur due to anaerobic conditions by the raised water table which create a suitable environment for the production of methane. Revegetation of *Sphagnum* mosses helps lowering methane emissions that arise after rewetting because *Sphagnum* mosses house methane oxidizing bacteria that consume methane (Kip et al., 2010; Kox et al., 2021).

Principle three of the SER states that restoration should be informed by a native reference system while considering environmental change (Gann et al., 2019). For peatland restoration, this means considering the hydromorphological type and restoring based on this. As expressed by the practitioners the hydromorphological type (fen or bog) is considered, and restoration methods are adjusted to accommodate accordingly. Whether environmental change considerations are well integrated will be discussed in 4.4, but native reference systems are well integrated in practice.

Principle four of the SER states that restoration actions should support ecosystem recovery processes, meaning that restoration aims to reinstate components and conditions suitable for ecosystem recovery (Gann et al., 2019). For peatlands this means restoring the water table, and creating conditions for vegetation recovery, sometimes by active revegetation according to my participants. Many participants expressed that the hydrology is recovering well after restoration, but Kyrkjeeide and Wien expressed the need for more ecological restoration (revegetation).

4.3 What is the state of current monitoring, how can monitoring improve, and are the national goals being achieved?

From the interviews, three subjects emerged; merge monitoring, improve monitoring, and upscale monitoring. Currently, the intensive monitoring, hydrological monitoring, and greenhouse gas monitoring projects do not have access to each other's monitoring data. This makes it impossible to find relationships between data sets. For example, without the hydrological data, analysing and understanding greenhouse gas emissions, or vegetation data is difficult, as the data together reflect the ecosystem of the peatland. In a peatland, the plants, water and peat are closely connected and influence each other (Schumann & Joosten, 2008). The plants determine the type of peat that will establish and thus the hydraulic properties of the peat, whereas the hydrology determines what plants may establish and thrive, the storage of peat and the decomposition of the peat (Schumann & Joosten, 2008). The structure and the hummocks and the hollows in the peat determine how the water will flow and fluctuate. The interrelations between the plants, water, and peat mean that when one of these components changes, the others will change too (Schumann & Joosten, 2008). This means that all data are needed to assess restoration success, supporting the claim from the participants to merge the monitoring programs. For improving the monitoring, an important suggestion is to follow the BACI design. The BACI design includes monitoring before and after at the restoration site and a reference site. This way monitoring focuses just on the effects of the restoration actions, and not on other phenomena influencing the restored site (Conner et al., 2016). Following the BACI design for monitoring would allow SNO to better separate the effects of their restorative actions from other outside influences on the peatland. Three participants believe vegetation monitoring would improve by using plots instead of transects because according to them, it provides more representative data. The need for more monitoring was also addressed. This is because only having five detailed (species level) vegetation monitoring (Kyrkjeeide et al., 2021), four hydrology monitoring sites, and one greenhouse gasses monitoring site, does not provide enough data to be representative of all restored peatlands. At the moment only publications by the vegetation monitoring program are available. Bonnett et al. (2011), confirm the need to monitor before and after restoration, and ideally, the monitoring methods should be compatible with past/other surveys. Due to the national monitoring program in Norway (ANO) using plots for monitoring vegetation, peatland monitoring programs should include this as well.

Achieving the national goals revolves around re-establishing peat accumulation. Restarting this process means carbon storage, restoring adaptation functions, and habitat recreation

(Miljødirektoratet, 2020). However, as of now, there is a lack of long-term studies to determine whether rewetting can accomplish this goal (Kløve et al., 2017), nor are there data for Norway. What we do have are visual inspections by practitioners and scientists. When evaluating the attainment of the goals, all three practitioners reported that, based on visual examination, the hydrological and ecological conditions are gradually progressing towards pristine conditions, indicating potential goal achievement. The practitioners said that the water table has risen, and *Sphagnum* species are revegetating the restored sites. Two scientists agreed with the interpretation of the practitioners, one scientist did not. Based upon his knowledge of the earlier restoration projects, Halvorsen mentioned that the water level is too high for *Sphagnum* species to establish, and the use of heavy excavators is damaging the peat. Lyngstad and Kyrkjeeide agreed that the earlier restoration projects from SNO did not achieve restoration success but have since seen a steep learning curve in restoration methods and excavator use. The current use of excavators in Norway, with measures to minimise peat compaction, is in line with the LIFE-handbook (Pakalne et al., 2021). Halvorsen stated that the water level after restoration is too high, and forms flark pools, i.e., small depressions that fill up with water, in which *Sphagnum* species do not establish. Rochefort et al. (2002) supports Halvorsen's view because depressions are prone to flooding after heavy precipitation or snowmelt. When *Sphagnum* floods the tissue water content gets too high which decreases the photosynthetic rate, resulting in inhibited growth (Rochefort et al., 2002). Eid agreed that in the first phase after restoration the site appears to be too wet, but he stated that this problem mitigates itself. Upon rewetting the peat sucks up the newly available water and starts to swell up. Due to the peatland swelling up, the water level starts to lower relative to the peatland, resulting in a good water level. This surface motion by peatlands provides resilience during dry periods, by shrinking in size to match available water levels (Bradley et al., 2022). Due to lacking monitoring on restoration success in Norway, there is no data to support Halvorsen or Eid. Similar to Norway, Finland is restoring many peatlands that were drained for forestry. A ten-year study on the effects of restoration, after ditch blocking and removal of trees, shows that the water table and the peatland vegetation recover (Haapalehto et al., 2011). While many typical peatland species were still missing, overall rewetting led to the reversal of drainage effects (Haapalehto et al., 2011).The similarities in restoration methods between Norway and Finland (ditch blocking and tree removal) suggest that at least for the newer restoration sites there to be no substantial water damage. This is supported by the visual inspection by the practitioners in Norway, who observe water table and vegetation recovery. Because Lyngstad and Kyrkjeeide agreed with Halvorsen that older restoration projects did not look as good as the newer ones, and Halvorsen basing his analyses on these older projects, Halvorsen was probably right in saying that these earlier restoration projects were not successful. The difference between Halvorsen, and Lyngstad and Kyrkjeeide lies in their knowledge of current restoration projects. Lyngstad and Kyrkjeeide are aware of the newer restoration projects due to their work in the intensive monitoring program. Not until more monitoring gets established and the data are analysed will we know for certain if the national goals are being achieved, but visual inspection suggests that, at least for newer restoration sites, good progress is being made.

The sixth principle by the SER states that ecological restoration seeks the highest level of recovery attainable. Eid stated that within SNO they try to restore in such a way that they never have to go back with additional actions. If needed, additional actions can be implemented, but the goal is to restore as completely as possible. SNO seemed committed to reaching the highest possible outcome and principle six, but due to limited monitoring, it is currently hard to assess whether projects are achieving the highest level of recovery possible. Just like many participants addressed, if SNO wants to perform better on this principle monitoring needs to scale up.

4.4 What is the function of peatland restoration within climate change mitigation and adaptation in Norway and does climate change affect restoration?

All participants agreed that peatland restoration plays an important part in climate change mitigation and adaptation, but restoration efforts need to scale up to have significant impacts in climate change management. According to the participants, stopping current CO_2 emissions from degraded peatlands is the main mitigation function of peatland restoration. Currently, degraded peatlands are emitting large amounts of CO_2. Joosten et al. (2015), estimates annual emissions of drained peatlands to be 5 to 10 million tonnes of CO_2-equivalents, which corresponds to 10 to 20% of the total Norwegian emissions, and highlights the importance of peatland restoration in Norway. At present, SNO is mostly restoring peatlands that were converted to forest, but restoring peatlands that were converted to croplands or grassland would result in emission reductions up to ca. 15 times higher (Joosten et al., 2015). When the goal is to reduce carbon emissions, Norway needs to start restoring peatlands drained for agricultural purposes

The participants mentioned that climate change is having both positive effects, due to higher biomass production, and negative effects due to dryer conditions, on peatlands in Norway. Warmer and wetter conditions result in faster *Sphagnum* species growth, and thus peat accumulation, while warmer and dryer conditions result in diminished *Sphagnum* species growth. A report published by Norway´s environmental agency supports the claims from the participants, stating that by the year 2100, there will be an estimated temperature increase by 4.5 °C, more heavy and intense rain events and more droughts resulting in an increased soil moisture deficit (Hanssen-Bauer et al., 2017). Two participants proposed to start strategizing which peatlands to restore based on (future) climate change. When considering the large timeframe of peatland restoration, recovery after the initial restoration measures can take decades (Kreyling et al., 2021), and future climate change needs to be considered. Hobbs (2012), is a pioneer in this field, and advocates for integrating a changing climate and environment in restoration activities. Changing environmental conditions due to climate change are forcing peatland restoration to strategize which peatlands to restore if restoration practices want to achieve the best long-term results. According to Lyngstad, this means focussing on the south-easter part of Norway, due to the dryer conditions. He believes focussing on this area would have a bigger climate change mitigation impact compared to other, wetter parts of Norway. A study from Great Britain suggests the opposite (Gallego-Sala et al., 2010). Many parts of Great Britain would no longer be able to host peatlands due to future climate change creating dryer conditions, which suggests focussing restoration efforts on the areas that remain able to host peatlands. While Halvorsen admitted that peatlands are sensitive to climatic change, he stated that Norwegian peatlands are relatively safe from the effects of climate change. This is supported by literature showing that northern peatlands will keep gaining carbon under climate warming scenarios during the 21st century (Chaudhary et al., 2020; Gallego-Sala et al., 2018). While peatlands located south of Norway, between 45 and 55°N latitude, might lose carbon in the near future, Norwegian peatlands are above this range and will keep accumulating carbon into the future (Chaudhary et al., 2020). This supports Halvorsen´s view on the effects of climate change on Norwegian peatland systems and Lyngstad´s view on how to maximize the climate change mitigation effect of restoration. Principle three by the SER confirms the importance of considering environmental change, as it states that restoration should be informed by a native reference system while considering environmental change (Gann et al., 2019). Environmental change includes both a changing climate and human influence, and both of these can force restoration goal adjustment. This adds to the evidence that peatland restoration should focus on peatlands located in regions experiencing drought.

The participants mentioned the need to take methane emissions into account. While restoration is needed to stop high CO_2 emissions, upon rewetting the new anaerobic conditions results in higher methane emissions (Kox et al., 2021). As mentioned earlier, *Sphagnum* cover reduces methane emissions and it is thus important to achieve fast *Sphagnum* species establishment after restoration (Kip et al., 2010; Kox et al., 2021). Measures to take away unwanted vascular plants and revegetation with *Sphagnum* fragments can help accelerate recovery after restoration (Järveoja et al., 2016). Overall, the participants agreed that methane emissions need to be considered, but stopping CO^2 emissions is more important. This is supported by the decay rates of methane and CO^2, the latter being a weaker but more persistent greenhouse gas, whereas methane is a short-lived but stronger greenhouse gas (Günther et al., 2020). This adds a time component to the climate change effect of peatland restoration, but postponing rewetting would increase long-term emissions through continued CO^2 emissions (Günther et al., 2020).

4.5 What are the organisational difficulties for peatland restoration?

All participants addressed that upscaling restoration efforts are required to achieve the climate mitigation and adaptation goals and to recreate sufficient habitat. This corresponds with the seventh principle by the SER, which states that ecological restoration gains cumulative value when applied at large scales. Many ecological processes function at a landscape, watershed, and regional scale and restoration are most effective at these scales (Gann et al., 2019). Currently, peatland restoration in Norway does not work on these scales but has focussed on single peatland systems. To have a significant impact on the national goals peatland restoration needs to upscale towards landscape, watershed, and regional scales.

As addressed in chapter 4.4, current emissions from drained peatlands are very high, and according to many participants upscaling restoration is the only way to lower these emissions and have significant climate change mitigation and adaptation impact. According to the participants, the issue of upscaling restoration revolves around three obstacles; legal limitations, stakeholder involvement when restoring outside protected nature, and limited human capital. Both scientists and practitioners addressed the difficulties of restoring outside protected nature areas. Within protected nature areas, there are few stakeholders, for example, land owners, who can stop the project, but outside of protected nature areas, there are few tools to support restoration efforts (Rusch et al., 2022). The lack of restoration efforts outside of protected nature areas is severely limiting the emission reduction effect peatland restoration could have in Norway because emissions from peatland converted to grass and croplands are much higher than in forested areas (Joosten et al., 2015). This corresponds with my participants addressing the need to upscale restoration and be more aggressive towards the agricultural sector. Lastly, limited human capital is restraining what restoration in Norway can achieve, currently, there are not enough people to upscale restoration and monitor activities. Bringing more people into restoration is going to be the key to upscaling restoration.

The first principle of the SER promotes good stakeholder engagement. The SER focuses primarily on local residents, and they see that their enthusiasm for the project can either make or break it (Gann et al. 2019). This is extremely relevant for peatland restoration in Norway, as local residents, mainly landowners, need to give consent to the restoration projects. Due to the current focus on peatland restoration in protected nature areas in Norway, local residents are relatively unimportant in the success of a project. When peatland restoration seeks to move beyond restoring in protected nature areas, a focus on local resident involvement is going to be vital according to Lyngstad and Eid. In the end, the landowners have the final say in deciding whether restoration is allowed to proceed.

Both practitioner Eid and scientist Halvorsen addressed the need to reach beyond SNO's in-house expertise. This need is in line with the second principle by the SER, which states the need to incorporate practitioner experience, traditional ecological knowledge, local ecological knowledge, and scientific discovery in the restoration process. Within SNO, practitioner experience is very well integrated within the restoration process. Eid, Wien, and Skutberg have gathered much experience which is integrated into the restoration process. Halvorsen believes better scientific knowledge integration is needed for restoration success. He proposed that SNO organises a discussion with peatland experts to address the future of peatland restoration in Norway. Indigenous people have gathered much traditional ecological knowledge about their environment, which can be helpful when restoring this environment (Gann et al., 2019). The SER defines local ecological knowledge as; *"local, place-based knowledge of the land and its processes applied by humans to create more productive lands and healthier ecosystems, increasing biodiversity and improving ecosystem resilience",* local ecological knowledge is prevalent in places where traditional knowledge is lost, but local inhabitants have gathered ecological knowledge about a place (Gann et al., 2019). In the restoration practice in Norway, these two types of knowledge are not integrated. As expressed by multiple participants, there is no data on where all the ditches in Norway are, which is hindering the restoration process. Traditional and local knowledge can help in this scenario. Often land users and owners are well aware of their landscape, and SNO should use this knowledge and provide a platform for landowners to report ditched peatlands.

According to the eight principle, restoration should be part of a continuum of restorative activities. A restorative continuum are activities ranging from reducing impacts to large scale ecological restoration. The interview results do not include data on restorative activities in Norway besides peatland restoration, and thus I cannot expand on these. Due to it being a continuum and the restorative activities overlap, it is hard to say exactly where SNO's restorative activities stand, but they reside in rehabilitation and ecological restoration. The National goals are mostly focused on recovering ecosystem services (rehabilitation), but the restorative activities from SNO focus on restoring native ecosystems (ecological restoration).

Just like Eid stated, Norwegian nature will need many types of restoration, and for this, the whole restorative continuum will be needed.

4.6 Future prospects and management implications

My synthesises is useful for the practice of peatland restoration in Norway, as it provides an expert opinion on the performance of SNO, places Norwegian peatland restoration in an international context, and highlights the improvement pathways for peatland restoration in Norway. While the lack of data supports the need of this thesis, it also restricts its synthesis. This is due to peatland restoration being a relatively new practice, resulting in a scarcity of data making it hard to compare Norwegian restoration practices to long-term studies.
Overall, the scientists were more negative regarding the older restoration success, but developed a more positive outlook on the newer restoration projects. The practitioners were overall positive regarding the restoration success. Based on the interviews I found a strong need to reshape the national goals for peatland restoration in Norway, which should incorporate the fifth principle by Gann et al. (2019). To upscale restoration, principles one (stakeholder engagement) and seven (gains cumulative value when applied at large scales) need to be better integrated. Principle seven highlights the importance of upscaling restoration and without better stakeholder engagement restoring outside of protected nature areas will not come to fruition. SNO will need to incorporate more ecological restoration in their practices, especially *Sphagnum* species revegetation on sites with bare peat to promote recovery and lower methane emissions. More monitoring data that can be used to assess the restoration success of peatlands are required to achieve the national goals. For this, monitoring actions need to scale up, separate monitoring projects need to merge or at least share their data, and monitoring should follow the BACI design. Because peatland restoration takes a long time and aims to secure restoration success far into the future, changing environmental conditions need to be considered in today's peatland restoration. Norway's environmental agency needs to compose a strategy that focuses on peatland areas that will become dryer due to climate change. Lastly, upscaling restoration efforts are of great importance to reach the national goals, and should start with attracting more people into restoration, as this enables possibilities to deal with other upscaling challenges like legal difficulties and stakeholder involvement.

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Appendix

There are a few minor differences between the scientists interview guide and the practitioners interview guide. Due to the nature of the interviews, not all questions were asked during every interview. Some participants had extensive knowledge on certain topics, which were then more extensively discussed.

Interview guide for scientists

Theme	Question
Setting the stage	• Please introduce yourself and state your position in peatland restoration in Norway, what is your background, expertise, work experience, etc. • Is it okay if I record the interview?
Goal setting/ achievement	• What is the main goal for peatland restoration at the moment? What should it be?
	• Are the approaches for peatland restoration in Norway accomplishing the set goals? For the peatlands you monitor, and the ones from SNO.
	• should there be more flexibility or should there be more rigid standards within restoration projects? *Higgs, et al. (2018) argue to put Principles above Standards, as it leaves more room for flexibility for restoration practitioners than a standards-based approach.*
	• Currently, SNO monitors species groups to base restoration success on. Do you believe this to be sufficient, or is there a need for species level monitoring?
	• What is the timeframe for restoration success for the peatlands you monitor. And what about those from SNO?
	• Do you believe there are any trade-offs in restoring for ecosystem services (like carbon storage), compared to restoring towards a historic trajectory (mimicking what there was before human alteration) for peatland restoration?
Restoration methods	• How do you believe peatland restoration in Norway/ Statens naturoppsyn (SNO) to be performing? Are there aspects you would like to improve on, and what are they doing well?
	• In the field, sphagnum growth is often used as a proxy for peat accumulation/restoration success. How reliable is this?

	• How does the restoration process look like in the field? What is the step-by-step approach to restoring a peatland ditched for forestry?
	• Do, or should, restoration methods differ between peatland types in Norway? For example: are/should there be differences in restoring a bog, or a fen? What are the differences?
	• How would you monitor a restored peatland? What indicators would you use to determine success?
	• As you probably know, raised bogs are currently the most often restored mire sites. In what way would restoration methods be different for other types? Sloping fen, blanket bog
	• I read up on three restoration strategies, Inundation (ditch blocking and letting the water come if immediately), topsoil removal (where the degraded top layer is removed), and Slow rewetting (where the water inlet is controlled and water is introduced again slowly). What are your thoughts on these methods, and which one is most applicable for Norway?
Climate change	• How important is peatland restoration for climate change mitigation in Norway?
	• What is the role of peatlands, and peatland restoration, for climate change adaption in Norway?
	• Are there negative implications for the climate due to peatland restoration? - Could you tell a bit more about how to avoid negative climate effects due to restoration?
	• Is climate change negatively affecting peatlands in Norway, and or is it affecting the restoration process?
	• What are the consequences of warmer (wetter, or dryer) climates to peatlands in Norway? • If peatlands are negatively affected by (future) climate change, can or should, restoration practises change in order to make peatlands more climate change resilient? • Is/should climate change taken into account during the discission making process? (site selection), should it be included more? For example: restoring peatlands in the north?
	• Do you think peatland restoration gets adequate focus in the climate change debate in Norway?
	• How does Norwegian peatland restoration involve (local) stakeholders, and should it improve?

Stakeholder involvement/ organisation	• Do peatland restoration practitioners/scientists in Norway have influence on larger-scale landscape planning? • Is there gains to be held by integrating peatland restoration in larger scale landscape planning? *Ecological restoration gains cumulative value when applied to large scales (Gann et al., 2019). For example, carbon sequestration or water security become more influential in bigger areas.*
	• Who decides on the restoration objectives and targets to pursue in peatland restoration in Norway? Who should do this? What are the implications of this?
	• What are currently the main challenges for peatland restoration in Norway?
	• What are the likely losses to the value of natural capital, and society if no, or insufficient, action is taken to halt degradation?
General questions	• What are Norway's best qualities in peatland restoration?
	• What are the main knowledge gaps in peatland restoration in Norway?
	• Are there any conflicts within peatland restoration? Examples: land-use conflicts, agriculture, private versus public land.
	• Where does peatland restoration sit comparatively to other ecological restoration projects in Norway? For example versus forest restoration and funding differences or political will.
	• Are there any topics you feel like we missed and would like to add?

Interview guide practitioners

Theme	**Question**
Setting the stage	• Please introduce yourself and state your position in peatland restoration in Norway, what is your background, expertise, work experience, etc. • Is it okay if I record the interview?
Goal setting	• What is the main goal for peatland restoration at the moment? What should it be?
	• Are the approaches for peatland restoration from SNO accomplishing the set goals?
	• Which do you believe to be better for reaching the goals of peatland restoration in Norway, standards, or principles? In other words, should there be more flexibility or should there be more rigid standards?

	<u>Principle</u>= serves as the foundation for particular beliefs. Often generates guidelines/standards for practice. *Example: restoration should aim for the best possible outcome.* *<u>Standards</u> = used as a comparative measure or norm.* *Standards are typically prescriptive and provide detailed and measurable guidance.* *Example: Sphagnum growth measurements every 4 months?*
	• When do you decide a restoration project to be successful?
	• What is the timeframe for restoration success. If restoration success is Sphagnum growth, how long does this usually take?
	• Do you believe there are any trade-offs in restoring for ecosystem services (like carbon storage), compared to restoring towards a historic trajectory (mimicking what there was before human alteration) for peatland restoration?
Restoration methods	• How do you believe Statens naturoppsyn (SNO) to be performing? Are there aspects you would like to improve on, and what are they doing well?
	• How does the restoration process look like in the field? What is the step-by-step approach to restoring a peatland ditched for forestry? • Could you expand on the preservation of top-layer vegetation? • I interviewed someone else (Rune Halvorsen) who is sceptical about using heavy machinery for restoration. What are your thoughts on the use of heavy machinery, are they necessary?
	• Do, or should, restoration methods differ between peatland types in Norway? For example: are/should there be differences in restoring a bog, or a fen? What are the differences?
	• What is the time-line from start to finish for a peatland restoration project in Norway? How long does it take, and when is a peatland considered fully recovered?
	• How do you monitor restored peatlands? Is this sufficient to understand their restoration process?
	• I read up on three restoration strategies, Inundation (ditch blocking and letting the water come if immediately), topsoil removal (where the degraded top layer is removed), and Slow rewetting (where the water inlet is controlled and water is introduced again slowly). What are your thoughts on these methods, and which one is most applicable for Norway?
	• How important is peatland restoration for climate change mitigation in Norway?

Climate change	• What is the role of peatlands, and peatland restoration, for climate change adaption in Norway?
	• Is climate change negatively affecting peatlands in Norway, and or is it affecting the restoration process?
	• What are the consequences of warmer (wetter, or dryer) climates to peatlands in Norway? • What will peatlands turn into in future climate? • If peatlands are negatively affected by (future) climate change, can or should, restoration practises change in order to make peatlands more climate change resilient? • Is/should climate change taken into account during the discission making process? (site selection), should it be included more? For example: restoring peatlands in the north?
	• Do you think peatland restoration gets adequate focus in the climate change debate in Norway?
Stakeholder involvement/ organisation	• How do you see the role of stakeholders in Norway? • How does Norwegian peatland restoration involve (local) stakeholders, and should it improve?
	• Do peatland restoration practitioners in Norway have influence on larger-scale landscape planning? *Ecological restoration gains cumulative value when applied to large scales (Gann et al., 2019). For example, carbon sequestration or water security become more influential in bigger areas.*
	• Who decides on the restoration objectives and targets to pursue in peatland restoration in Norway? Who should do this? What are the implications of this?
	• What are currently the main challenges for peatland restoration in Norway?
	• What are the likely losses to the value of natural capital, and society if no, or insufficient, action is taken to halt degradation?
General questions	• What are Norway's (SNO) best qualities in peatland restoration?
	• What are the main knowledge gaps in peatland restoration in SNO/ Norway?
	• Are there any conflicts within peatland restoration? *Examples: land-use conflicts, agriculture, private versus public land.*

	• Where does peatland restoration sit comparatively to other ecological restoration projects in Norway? For example versus forest restoration and funding differences or political will.
	• Are there any topics you feel like we missed and would like to add?