HANDBOOK

of Virtual Nature Interventions

– Insights from the NATUREACH Project (2023–2025)

Martta Niemi & Elisabet Bohlin (Eds.)

NATUREACH

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Abbreviations

PSD	Perceived Sensory Dimensions
CLM	Contemplative Landscape Model
VR	Virtual reality
OVR	Olfactory virtual reality

1 Preface

Virtual Reality (VR) technology offers new and innovative ways to experience nature while also providing an alternative for people who lack easy access to real natural environments. This handbook was inspired by the experiences in the NATUREACH project (2023–2025), with the main goal of improving human health and well-being by developing virtual nature service models for social and health care. We want to share the findings and lessons learned in developing virtual nature interventions for client groups with physical or psychological restrictions and other vulnerabilities. This handbook aims to provide a comprehensive guide on how to integrate virtual nature-based service models in social and health care, but also into the wider use of VR for health promotion.

Our multiprofessional team included expertise in VR-technology, multidisciplinary research, social and health care, and the competence of nature- and media entrepreneurs. The virtual nature-based interventions have been co-designed for five individual client groups in Sweden and in Finland: clients with developmental and physical disabilities, patients with eating disorder, patients in palliative care, patients with diabetes type 2, and clients in elderly care. The aim for virtual nature interventions was to generate optimal restorative and rehabilitative effects for each client group, but also to support the occupational health by offering easily used recharge-tools for care professionals to reduce stress-related symptoms and to support recovery during and after their demanding work shifts.

There remains very limited information available on the production of virtual nature interventions. During our development work, we conducted a number of experiments and findings that we would like to share with all actors interested in the topic to facilitate the adoption of virtual nature in their own practices.

Our experience and research showed that virtual nature can support the well-being of vulnerable client groups as well as social and health care professionals. Therefore, we would like to encourage all interested in the health promoting effects of nature and VR to make use of this handbook and the other materials we produced in our project (https://www.slu.se/en/natureach).

Picture 1. Virtual natural environment: Pine forest in morning fog (cinematography by Martin Gärdemalm).

2 Design and Production of Virtual Natural Environments

A high-quality virtual natural environment is the foundation of a successful digital nature-based intervention. But what does this mean in practice? In simple terms, it refers to a digital representation of a natural environment experienced through an immersive medium, such as a VR headset or a dome display. Within the NATUREACH project, and throughout this handbook, the focus is on virtual natural environments specifically designed to support health-promoting interventions.

When developing such virtual nature interventions, it is important to recognise that, though these environments are delivered as video files, they should not be regarded as conventional nature videos or films. Instead, they are immersive environments intended to evoke the experience of being transported to an authentic natural setting, thereby fostering a sense of "being away".

Viewers often approach nature media with expectations shaped by traditional filmmaking, where motion, momentum, and a predefined narrative structure are central elements. Virtual natural environments differ fundamentally from this format. They are not designed to direct attention or convey a storyline; rather, their primary purpose is to cultivate a sense of presence within the environment. This design approach allows users to explore and experience the setting independently and at their own pace, ideally through uninterrupted and continuous recordings. Such qualities closely align with the sensory characteristics

associated with "forest bathing" and other forms of nature- and animal-assisted therapy (see, e.g. Vermeesch et al. 2024).

This chapter offers guidance on the design and production of virtual natural environments, as well as criteria for selecting the most suitable options from existing, previously produced environments.

2.1 Restorative environments

Elisabet Bohlin, Ann Dolling, Anna María Pálsdóttir and Martta Niemi

The quality of virtual natural environment has a key role in well-being and health outcomes. The virtual natural environments produced in the NATUREACH project were designed with background knowledge of what nature types are the most restorative as well as which properties are considered the most important for human well-being. According to research, the most important properties are so-called *prospect-refuge,* i.e. a good view in front, a shelter in the back in a combination of open view and water nearby. These qualities are basic and signal survival. Additionally, one needs something natural for the eyes to rest on, such as old trees. The sounds must be natural as well. The wind, rustling of trees or birds softly chirping nearby can have a calming and restorative effect. Natural scents are important, and the skin's sensations of, for example, sun or wind also play an important role in the sensory experience. What this is really about is allowing the senses to "bathe" in natural experiences and a moderate level of stimulation. When feeling safe, the human brain "rests" in nature and begins to recover. The types of natural environments familiar from childhood can have an impact on later nature experiences and preferences. The earlier connection to real nature together with age and prior history can also modulate the experience in virtual nature and the effects of the intervention.

Here are examples of restorative natural environments, commonly referenced in environmental psychology and nature-based interventions for health and well-being:

- **Forests and woodlands**: old forests are preferred, as the trees need to be tall enough to create a sense of space and openness, with a high canopy. In the Nordic region, this usually means forests that are more than 80 years old. Ideally, the forest should also be biodiverse, as this helps create a feeling of refuge, soft fascination, and less sensory overload.
- **Water environments** (blue spaces): lakeshores, rivers, streams, waterfalls, wetlands, coastal areas and seaside environments like beaches, dunes, and rocky shores that combine rhythmic sounds, expansive views, and fresh air; water is strongly associated with stress reduction and attentional restoration.

- **Open landscapes**: meadows, mires, fields, grasslands, and pastoral landscapes that convey openness, calmness, and visual coherence with fewer man-made constructions.
- **Parks and green urban spaces**: urban parks, botanical gardens, and green corridors with vast biodiversity that offer accessible restoration in everyday settings.
- **Mountains and hills**: natural viewpoints and elevated terrains that promote feelings of perspective, awe, and mental clarity.
- **Therapeutic gardens**: healing gardens, sensory gardens, and courtyard gardens designed to support relaxation and recovery in care settings.
- **Care farms**: rural farm environments where domestic animals can be cared for or just observed as they graze and move about, reinforcing the feeling of living in the moment.

All these different types of restorative natural environments have their own natural soundscapes, characterized by, e.g. birdsong, wind in trees, flowing water or other natural sounds that enhance the nature experience. Also, seasonal changes in various natural environments can be highlighted (e.g. autumn forests, snowy landscapes, summer blossoms or spring and fall migration of birds), which can enhance the experience and engagement with the specific natural environment. In addition, the time of the day and the weather conditions can both enhance or diminish a positive experience of nature, depending on the individual's preferences and emotional state. During the project pilots, it became apparent that even stormy weather or a dark night can be experienced as a highly restorative and relaxing feature in virtual nature.

Pictures 2 and 3. Examples of virtual natural environments: Seaside cliffs (cinematography by Martin Gärdemalm) and Bay (cinematography by Esa Siltaloppi).

Restorative landscape assessment

To understand the potential of a restorative experience in the outdoor setting, particularly in natural settings, two diagnostic and design tools can be used to assess how well environments support human well-being, especially as related to *stress restoration and health*. The two tools are Perceived Sensory Dimensions (PSD) and the Contemplative Landscape Model (CLM), which reflect *human sensory and psychological responses* to landscapes and are often used in research on *restoration, well-being, landscape planning, and therapeutic environments.*

Both tools can be applied *in situ* (on-site) or to photographic/video representations of landscapes, making it flexible for various planning and research contexts. In practice it is used to assess existing spaces and create new outdoor environments aimed at enhancing human well-being.

Perceived Sensory Dimensions (PSD)

Perceived Sensory Dimensions (PSD) is an evidence-based framework describing how people *experience and perceive environmental qualities* in natural and green spaces. PSDs identify eight key qualities that people consistently recognise and value in outdoor environments.

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The eight Perceived Sensory Dimensions are:

1. **Serene**: peace, calm, low disturbance, natural sounds
2. **Nature**: sense of wild or self-grown nature
3. **Rich in species**: biodiversity and variety of life
4. **Space**: feeling of a coherent, open whole
5. **Prospect:** views, vistas, openness
6. **Refuge:** shelter, safety, protected spots
7. **Culture:** cultural or human-influenced features
8. **Social:** places to meet, interact, or experience others' presence

The PSD, **serene, nature, prospect, refuge, and space** were identified as the most important PSD qualities in the Alnarp Rehabilitation Garden context for rest and recovery. These dimensions were linked with psychological restoration, *attention restoration theory* components (such as fascination and being away), and everyday functioning improvements after rehabilitation. (Pálsdóttir et al. 2018.)

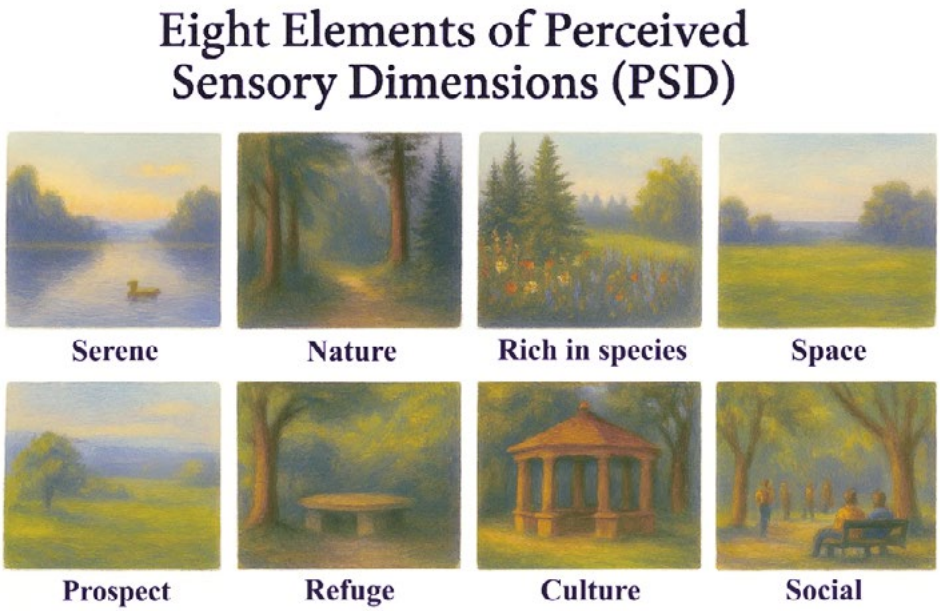


Figure 1. Eight elements of Perceived Sensory Dimensions (PSD) (Pictures created with MS365 Copilot).

Contemplative Landscape Model (CLM)

The Contemplative Landscape Model (CLM) is a research-based evaluation and design tool created to identify and assess landscape scenes that have the potential to support mental health and well-being through *passive exposure* – meaning people do not have to interact with the environment, they just need to be present in it. The model builds on insights from neuroscience, environmental psychology, and landscape design. Its aim is to guide urban planners, landscape architects, and policymakers in creating and evaluating outdoor spaces that can positively influence psychological states, especially in highly urbanised contexts where mental health burdens are elevated.

The CLM proposes that certain landscape qualities, when present in visual scenes, are more likely to trigger low-frequency brain activity associated with *reduced cognitive strain, increased relaxation, and positive affect*. These neural response patterns are linked to stress reduction and improved mood, making the CLM especially relevant for designing salutogenic and supportive environments.

Key Components

The CLM evaluates a landscape **view using seven components:**

1. **Layers of the Landscape:** depth and structuring of visual planes
2. **Landform:** shape and contour of the terrain
3. **Biodiversity:** variety and richness of living elements
4. **Colour and Light:** visual qualities that influence mood and perception
5. **Compatibility:** how well the landscape fits with its context and human use
6. **Archetypal Elements:** fundamental natural elements that evoke meaningful experiences
7. **Character of Peace and Silence:** overall sense of calm and quiet in the scene

Each component is scored on a 1 to 6 scale, and the average score indicates the landscape's overall contemplative quality; a higher score suggests greater potential for mental health benefits. (Olszewska-Guizzo 2023.)

2.2 Considering target groups and preferences

Elisabet Bohlin, Martta Niemi, Ann Dolling and Anna María Pálsdóttir

An intervention is something you do, introduce or change in a context to help, improve or influence a certain result. For example, it can be about a method, an activity or a support that is put in place to solve a problem or strengthen well-being. **A nature-based intervention** is about strengthening well-being and recovery by being in nature. The intervention thus has a clear purpose and is a planned effort for improving health.

The Rehabilitation Garden in Alnarp in Sweden is a good example of a nature-based intervention in which individuals suffering from mental fatigue and exhaustion were given the opportunity to rehabilitate in a specially designed garden environment. The rehabilitation programme was a mixture of the concept of "doing and being": i.e. it was embedded in garden and horticulture occupations (doing) in a combination with slow walk or sitting in a calm and secluded place (being). Research findings indicate that the most vulnerable patients chose the wildest and most forest-like parts of the garden, where no demands were placed on them along with the quality of "social quietness": i.e being along in and with nature. Qualities such as nature, rich in spices, prospect and refuges were particularly important in this context. (Pálsdóttir 2014; Pálsdóttir et al. 2018; Tenngart-Ivarsson 2011.)

Pictures 4 and 5. Alnarp rehabilitation garden (photos: Martta Niemi).

A research project in Umeå in Sweden built on the results from Alnarp and developed a rehabilitation programme in a forest setting – that is, in the most demand-free environment. In this nature-based intervention, participants were allowed to choose a forest environment and were then encouraged to sit in that environment for two hours and "just be". This type of practice, which combines forest settings with mindfulness exercise, is exemplified by "forest bathing". The most popular setting was the forest by the lake, which offered shelter behind, a view ahead, and proximity to water. The results showed that mood improved simply by sitting in a self-selected environment. (Sonntag-Öström et al. 2015; Dolling et al. 2017.)

The results showed that mood improved simply by sitting in a self-selected environment

Picture 6. Example of views selected in the Umeå study (photo: Ann Dolling).

The starting point for many of the virtual environments used in the NATUREACH project has been the results from the intervention in Umeå. The virtual environments were designed to include the qualities that aimed to support participants' well-being, such as a sense of space (prospect, a forward view), protection behind, wildness, biodiversity, and natural sounds. The design of virtual natural environments should take into account the objectives of using virtual nature interventions, such as recovery, calming down, reducing pain, anxiety or stress,

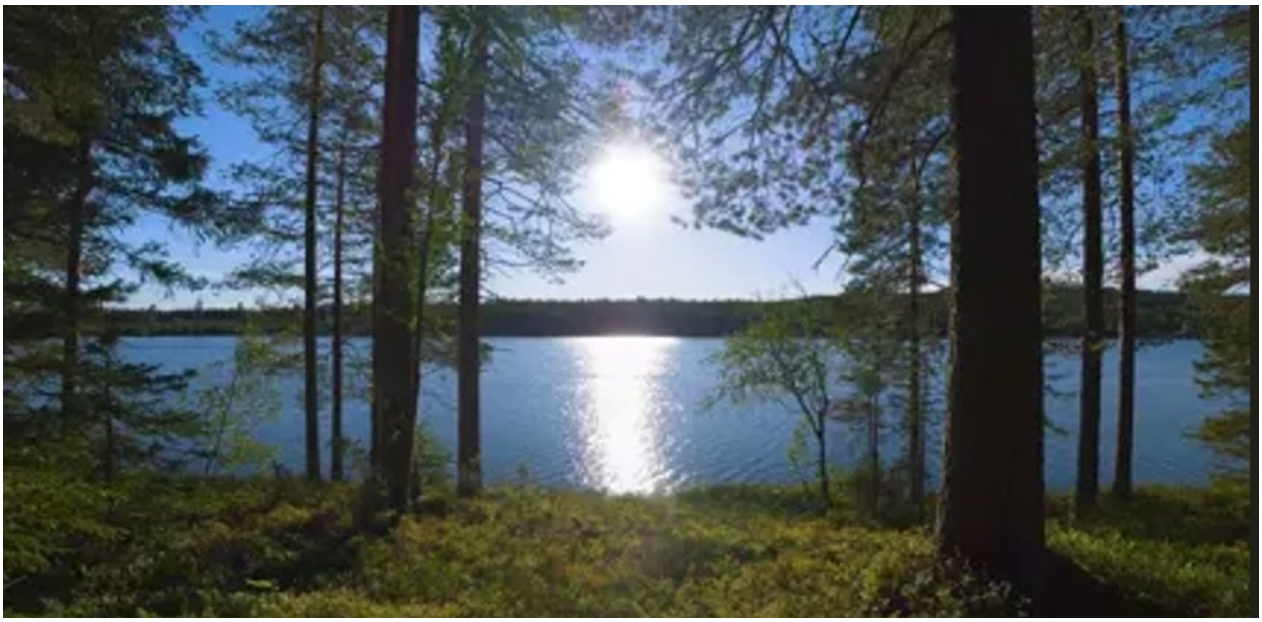
getting away from everyday life, or incorporating new stimuli and experiences into everyday care practices.

To examine the type of environments and natural features that could meet the goals of the various client groups, a vast variety of preferences can be presented regarding different types of nature (forest, lake, sea, river, mire), forest types (pine, spruce, deciduous forests), seasons (spring, summer, autumn, winter), time of day, varying weather conditions, and specific locations in various regions and countries. Some users may prefer a moving video where the viewer moves across the terrain or water environments. In addition, the preferable environments may include wild or domestic animals or even people. One example of mapping the clients' needs and preferences is presented in Appendix 1.

Due to the fact that suitable video materials may not be available and resources for the new productions of virtual environments are often limited, it is important to identify the key elements that unite preferences with the research findings from restorative, authentic and virtual natural environments.

It should be noted that, alongside accommodating individual requests, it is favourable to offer a variety of environments. Participants may discover unexpected benefits in settings they had not specifically requested, such as the evocation of positive childhood memories or other restorative and health-promoting effects. The project indicated that these unanticipated experiences could play a valuable role in perceived well-being, highlighting the importance of providing diverse environmental options rather than relying solely on pre-selected preferences.

Picture 7. Virtual natural environment: Sunny forest lake (cinematography by Martin Gärdemalm).



2.3 Video and audio production

Martin Gärdemalm,
Elisabet Bohlin,
Martta Niemi and
Janiv Oskár

Production of virtual natural environments is based on the ability to convey the sense of a natural environment digitally to the end user. In our experience, thorough advance planning of virtual environments ultimately saves a lot of time in actual video shooting and post-production. Still, not all shooting sessions result in a final video, but learning by doing has also been an important part of our virtual natural environment production process.

Some specific skills are needed when planning and producing health promotive virtual natural environments:

Some specific skills are needed when planning and producing health promotive virtual natural environments.

- **Understanding of the basic mechanisms of the well-being effects of nature** and the ability to apply it in a variety of contexts and objectives, whether regenerative, restorative, calming or activating and stimulating effects are desired.
- **Sense of place:** The ability to convey the specific characteristics and atmosphere of the site to the client. Ability to plan and select visually and soundscape-optimal filming and recording locations (including season, time of day, weather, etc.).
- **Technical skills:** The ability to use specific cameras and video and audio recording techniques (360, 180 or 2D screen video, still or moving video, drone, cloth, floating camera, etc.), with ambisonic or stereo sound.
- **Responsibility:** The ability to work responsibly in the terrain, including avoiding degradation or disturbance of sensitive natural environments and animals, respecting nesting seasons, respect for 'everyone's rights' (in Finland), obtaining necessary filming location permits and, where appropriate, consideration for the landowner and other recreational users of the area, etc.
- **Production management:** The ability to combine and productise rich and sprawling ideas into a high quality, feasible and economically viable virtual nature video and audio production.
- **Multisensory productions:** In addition, if the immersive audio-visual experience is to be enhanced with scents, tastes or tactile sensations, knowledge of these facilities and service providers with high quality is also needed.

Responsibility is a crucial part of overall quality of nature-based interventions connected to a wider concept of planetary health, aiming to enhance both social and ecological sustainability and well-being. Virtual nature interventions can diminish the negative environmental impacts that the use of sensitive natural areas can cause, while increasing the number of people who can utilise natural environments in a sustainable and health-promoting way. The use of virtual nature can thus increase inclusion by solving the challenges regarding limited accessibility to authentic natural environments.

However, the production and use of virtual nature may also have some negative ecological impacts. For example, birdwatching and birdsong are often considered elements that increase well-being in virtual nature. In video productions, care must be taken to ensure that filming does not disturb the nesting of birds. in Finland, the Nature Conservation Act prohibits the deliberate disturbance of protected animal species, especially during their breeding season. Virtual nature productions must be carried out in accordance with the principles of ecological sustainability and ethical conduct, so as not to disturb any protected animals. For the above reasons, filming domesticated and human-accustomed farm animals and pets may sometimes be a better option.

When purchasing VR equipment, special attention should also be paid to its longevity, upgradability, and recyclability. Renting the equipment is usually a better option for short-term use. In addition, continuous streaming of digital materials from the internet increases the use of natural resources and produces more emissions than the use of offline recordings.

Video production for virtual natural environments

Even though there are several common attributes associated with high-quality authentic and virtual natural environments, many important details are highly dependent on a specific use-case. For this reason, it is very important to begin any production with a thorough analysis of the specific needs and goals, including asking the very important question: Do we even need to produce something new, or can we find pre-produced environments that fit our needs? This section outlines how user needs and preferences informed the design principles and production choices of the virtual natural environments in the NATUREACH project.

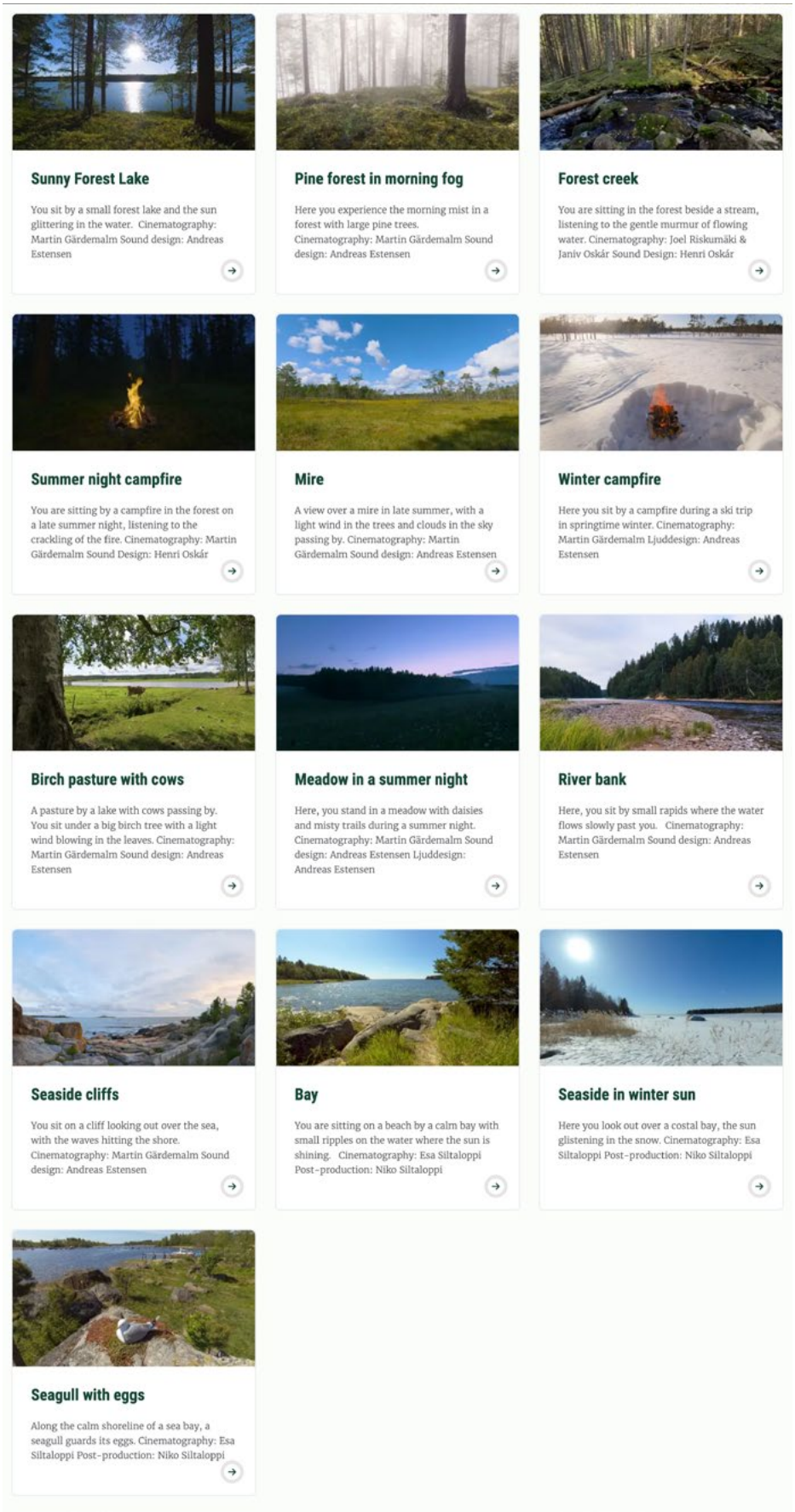
During the **pre-production phase**, user needs and preferences were identified through discussions and interviews with researchers and care professionals. Fully tailor-made and personalised environments were considered, but these were found to be unrealistic due to time, budget, and research constraints. The project therefore focused on shared needs and on developing a limited set of environments suitable for a broad user group.

Based on this, the environments were designed to feel familiar and evoke memories of nature, particularly from northern Sweden and Finland, while incorporating research-based restorative qualities. High audiovisual quality and immersion were prioritised, with 360-degree environments mainly produced for VR headsets, the most used format. The interventions were designed for seated users, with attention to comfort, motion sensitivity, and sessions of at least 15 minutes. A small but varied selection of environments was created to accommodate individual preferences.

» Incorporating research-based restorative qualities.

These principles guided the production of custom-made virtual environments rather than the use of pre-existing content. Real-world video recordings were chosen over computer-generated environments to enhance familiarity and authenticity. Production focused on high-quality 360-degree video, primarily using stationary cameras at a sitting height to reduce discomfort. Monoscopic video was mainly used to allow higher resolution and greater flexibility, while stereoscopic video was considered optional for selected environments. The project resulted in a selection of 13 custom-made 360-degree virtual natural environments recorded in northern Sweden and Finland across different nature types, seasons, weather conditions, and times of day.

Virtual natural environments produced in the NATUREACH project are available at: https://www.slu.se/en/natureach



Picture 8. Virtual natural environments produced and used in the NATUREACH project for VR headsets (cinematography by Martin Gärdemalm, Esa Siltaloppi and Janiv Oskár)

Scheduling and planning

Filming 15–30 -minute long 360-degree nature environments is highly weather dependent. We therefore recommend being flexible with your shooting dates and set aside long periods of time for potential filming. From our experience, we also benefitted greatly from being able to shoot more environments than we ended up using. Sometimes we also returned to the same place more than once to re-shoot. This gives the opportunity to select the absolute best shots for your final selection. This is particularly valuable if the aim is to avoid using cuts in the video if possible. This can increase the sense of realism but puts a lot more demand on getting a 'perfect shot' since cutting oneself out of a problematic part of that single take is not possible.

Filming 15–30-minute long 360-degree nature environments is highly weather dependent.

We also recommend setting aside plenty of time for location scouting, especially if equipment is not owned and it is necessary to rely on renting it on specific days. Since how much one can affect a wild nature environment is highly limited compared to a controlled interior, for example, finding the right environment that looks good in all directions is critical, as well as choosing the optimal time to shoot it.

Camera equipment

Firstly, as mentioned earlier, we recommend having flexible shooting dates. Therefore, buying long-term rent may be a better option than a short-term rental. Having the best camera in terrible weather conditions is worse than a lower-grade camera in perfect weather. That said, the choice of a camera is still very important for these types of productions, as it is one of the biggest contributors to the overall quality of the end-product.

Having the best camera in terrible weather conditions is worse than a lower-grade camera in perfect weather.

The world of 360-cameras is constantly evolving, and the same performance or reliability cannot be expected as that from "regular" cameras from well-established camera brands. If you have the opportunity, we recommend doing thorough camera tests yourself with the camera model/models you are considering, in addition to online research. Some quirks and differences may not be obvious until the camera is stress-tested for the particular use.

If you, like us, have already decided on the specific model of VR headset you will be using, it can be a great addition to your tests to view the footage in that headset. Some differences that may be obvious on a computer screen, zoomed in, may not be as obvious in a VR headset with lower resolution, for example. And some cameras that you hope will work well may turn out to be not good enough.

When looking for a suitable 360-degree camera, we recommend paying close attention to:

- **Resolution:** extra important for nature scenes with many fine details.
- **Image compression:** a high-res image from a 360-camera is often severely compromised by image compression. This is extra important for nature scenes with fine details and subtle changes in colours. Banding issues in clear skies should also be given attention.
- **Dynamic range:** a 360-degree view of a nature environment often puts extreme demands on dynamic range. Make sure to have as much range as possible.

A 360-degree camera often struggles with low-light. If you plan on extensive night shoots with high dynamic range, you may want to consider other options. For a night scene next to a campfire, we used an 8k mirrorless camera with a high-end 220-degree fisheye lens with good results. It should be noted that these types of set-ups may require more tests and planning, as well as different kinds of post-production software.

The type of VR equipment used in the interventions defines the optimal camera type, performance and technical solutions for video production to perform with high quality in the respective media. Visual virtual natural environments for VR headsets are created by videos shot with 360-degree cameras as well as standard cameras with fisheye lenses.

Picture 9. 360-degree video shooting by the lake (photo: Elisabet Bohlin).

Finding the optimal shooting locations and conditions

The design of our virtual natural environments is heavily inspired by the concept of "forest bathing". Even if we did not exclusively use forest locations, we mostly kept the core idea of using spots that encouraged relaxing and appreciating the environment. When arriving at your shooting location, make sure to have plenty of time to walk around and look for a perfect place to put the camera. Assuming you have not selected an exact spot during pre-production scouting, we recommend having at least an hour on the site before starting the recording. Depending on the complexity of the scene of course. This provides time to find the perfect composition, move distracting dead branches, wait for the sun to move into a better position, and wait for clouds to change, etc.

Make sure to have plenty of time to walk around and look for a perfect place to put the camera.

What to look for

Our most important philosophy when selecting a spot to put the camera is to place it where one would like to sit in real life. It is easy to get caught up in photographic composition and technical limitations, etc., and forget that part.

Other things to consider are:

- **Opportunities for movement in the image**: Running water, wind in trees and grass, clouds in the sky, animals, etc.
- **Nice view ahead** (often the horizon): Of course, a 360-degree video does not have a fixed "view ahead"; rather, it starts in a predetermined spot, and we want to make sure that this spot has a good and interesting view.
- **Safe backside:** On the opposite side of the "view ahead" we recommend to, if possible, have something to make the viewer feel more protected and safe: for example, a big tree or rock.
- **Interesting foreground**: In a 360-degree video, the visual elements close to the camera can take a lot of one's focus and often appear sharper than things further away. Having a good foreground can improve the scene considerably, but it is easy to neglect this.
- **Ideally, avoiding man-made objects** such as houses, cars, fences, roads, power lines or other objects that distract from the feeling of being in nature. If necessary, some things can be removed in post-production, but it is often easier and safer to not include them in the first place.
- **Consider the sun and its movement**: The sun can move a considerable distance in 15 minutes. Having the sun partially covered can be a good

way to avoid lens flares and ghosting, if that is something that bothers you. However, it comes with the potential downsides of compromised composition and shady, dark foreground. Even so, it is a method we have used many times in the project.

Weather

In the NATUREACH virtual nature selection, we offered different types of weather. It is easy to think that everyone just prefers sun and clear skies, but depending on the person and their mood from one day to another, this may not be the case.

One of the trickiest types of weather to shoot can be partly sunny weather with thin veil clouds close to the sun, as they easily become over-exposed and ugly. It may be a subjective preference, but we would recommend shooting when there are completely clear skies or different kinds of clouds if you are looking for a sunny feeling.

Even if wind can be difficult since it may correlate with changing light conditions, we would still recommend also shooting in windy conditions, since this adds considerable movement and life to the image when the foliage, grass, etc., moves. That said, the wind may nevertheless complicate audio recording.

In addition to weather-related factors, the final image quality is also strongly influenced by technical production choices. The final visual quality of a 360-degree video depends on multiple technical factors in addition to weather

Picture 10. Field work in winter (photo: Alina Fefelova, ISLE Art Industries).

and lighting conditions. Besides appropriate camera settings for the prevailing conditions, image quality is influenced by the camera brand and model (as different devices have distinct optimal settings and performance characteristics), possible hardware upgrades, and software updates related to the stitching process prior to 360-degree video editing. For this reason, both hardware and software should be updated well in advance of filming, followed by extensive testing to determine the most suitable shooting and stitching settings for different weather conditions.

With current 360-degree camera technology, technically optimal shooting conditions are often achieved on a fully overcast yet bright day. Such lighting allows for more even exposure, reducing excessive dynamic range between highlights and shadows. This helps minimize noise in darker areas and prevents bright areas from becoming overexposed, resulting in sharper image details. As 360-degree camera sensor technology continues to develop toward the color rendering and dynamic range typical of cinema cameras, high-quality filming will become increasingly feasible in a wider variety of weather conditions.

Audio recording for virtual natural environments

Auditive experience is one crucial element in creating an immersive virtual nature intervention. An important issue to consider is the quality of the auditive environment of the selected video shooting location before the production phase.

Auditive experience is one crucial element in creating an immersive virtual nature intervention.

A common issue you may encounter is that an environment that looks wonderful visually has suboptimal audio conditions. It can be challenging to find visually suitable filming locations that also offer a high-quality nature sound environment, due to traffic noise, wind turbines, peat mining or other industrial auditive landscape impacts that per se will not disturb the visual environment in the shooting location. Even natural sounds, such as strong wind, or nearby running water can sometimes be distracting or overwhelming. The "natural" soundscape also often lacks the more sought-after sounds, such as birdsong.

For this reason, it is strongly recommended to not rely completely on sync-sound but to allocate resources to build or enhance the soundscape in post-production by using natural sounds recorded in respective nature areas or acquired from suitable audio-sample suppliers. Unless the audio conditions are very noisy or completely silent, it is still recommended to record synchronised sound at the same time as the video if possible. It can be useful as a realistic base that can later be enhanced or, at the very least, as a reference when designing the new soundscape.

To determine the importance of the sync-sound for a given environment, one should consider the elements in the environment where movements and sound are connected.

SOME EXAMPLES WHERE SYNC-SOUND IS VALUABLE ARE WHEN

- animals are present
- there are strong and fluctuating wind-affecting trees, grass, etc.
- visible waves are hitting the shore
- there is visible running water in the environment
- a campfire is in the scene

When adding sounds in post-production, we strongly recommend aiming to ground it in realism: For example, to add birdsong from species that could realistically have been in the environment, and the song is timed according to the season and time of day. Using native birds can also be a valuable way to bring up memories for the viewer and create a stronger feeling of immersion. In Finland, for example, the BirdNet application (https://birdnet.cornell.edu/) have collected a comprehensive list of bird species with soundtracks that nest and occur in the area, based on spatial data.

Picture 11. Combining video and audio recordings in the mire environment (photo: Elisabet Bohlin).

Checklist for production of virtual natural environments:

- Choose the shooting location according to the goals and specific requests regarding environmental characteristics: what nature types are the most restorative and which properties are the most important for the well-being of the target group?
    - Environments should have science-backed restorative characteristics. Include restorative elements, e.g. a good view, shelter, water, +80 years old forest, sounds from a large number of bird species, etc.
    - Consider the specific preferences of the target group (roots, history, nature connection and social background). Environments should feel familiar and ideally evoke memories from childhood and time spent in nature.
- What is the best location regarding the view, camera spot and camera angle, and the best time to shoot?
    - The users of VR headsets and other immersive VR equipment will be mostly stationary (sitting). Carefully choose a natural spot where you would sit when you rest in nature, with a long, good view and shelter in the back (e.g. forest bathing).
    - Place the camera on the optimal height, which is slightly lower than a normal sitting height.
    - Length of the interventions is at minimum 15 minutes: Environments should accommodate that in a good way. Consider the duration of the video and possible changes in sunlight and shadows.
- What equipment will be used in the interventions (VR headset, dome, etc.) and due to this, what kind of camera and recording technology with audio production will be needed (monoscopic/stereoscopic, 360-degree/180-degree, audio format)?
    - The 360-degree format is preferred over 180-degrees (in a VR headset) to increase immersion and encourage the user to more freely explore the visual aspect of the environment.
    - Audio-visual quality should be prioritised. Choose sound equipment and a camera of good enough quality! If the quality is poor, the effect can be negative.

- Mix the sound properly, not only direct record in nature.
- Choose appropriate nature sounds that fit the environment, biodiversity, location and season (e.g. bird sounds, leaves, water, wind etc).
- Remove disturbing sounds and level all sounds to a comfortable mix.

- Will special equipment be needed for filming such as a mountain bike, boat, canoe, drone, cable technology, etc.? Are natural environments filmed with a moving camera?
- Is the site already a popular tourist destination and, if so, can access to the site be restricted for the duration of the filming session?
- Are other practical arrangements needed (e.g. making a fire, possible landowner considerations)?
- Does the production plan meet the budget and time resources? If necessary, make a contingency production plan.

Picture 12. Video production in a sunny forest (ISLE Art Industries).

HOW TO WORK WITH INSECTS AND OTHER ANIMALS?

When shooting videos in summer, insects can easily gather round the camera and cause interference. This can be reduced by using ecological insect repellents. Domestic animals can also be challenging to capture into a video, as they often act and move very spontaneously and may react to the filming situation and equipment with curiosity or fear. It is a good idea to plan the location for the filming in advance with the animal keeper, choosing a place that is familiar and peaceful for the animals, and to schedule the filming for a time when the animals are calm or, for example, eating. The camera should be placed in a location where it causes as little disturbance as possible and where animals cannot knock it over or touch it.

Picture 13. Virtual natural environment: Birch pasture with cows (cinematography by Martin Gärdemalm).

Dome-optimised video production

In the VR dome, but also in a VR cube and cylinder, the image is projected onto a screen or other surface using several projectors, which places demands on both the darkening of the studio room and the characteristics of the video. In our experience, videos with very little light at night, or similarly in a bright snowy environment in cloudy daylight in winter, are not optimally transmitted through the projectors, and the view is either too dark or overexposed. When filming in the forest, slightly cloudy weather brings out the various shades of green and the impression of depth better than bright, direct sunlight.

The VR dome is a very different viewing platform compared to VR headsets. The difference can roughly be compared to that between watching content on a television versus a projector. In VR headsets, resolution—that is, the number of pixels—is one of the most decisive factors affecting perceived image quality. In projector-based environments such as a VR dome, however, other factors become equally or even more important, including projector brightness (ANSI lumens), color reproduction, and the alignment of projected images relative to one another. Projectors with high brightness and accurate color reproduction are better able to display details in both shadowed and bright areas of the video image.

The VR dome is a very different viewing platform compared to VR headsets.

Physical characteristics of dome theaters also create specific challenges. Due to the curved projection surface, increasing light output to improve brightness may simultaneously increase light spill. Projectors with good color reproduction can better distinguish subtle tonal differences in both shadow areas and the brightest whites, which strongly enhances the sense of immersion and experiential quality. Careful VR dome optimization ensures that videos are reproduced in the space as intended, that color rendering is accurate, and that projectors are aligned precisely to avoid image softness or ghosting artifacts.

Since the dome offers a 180-degree view, there are more possibilities for video filming when the cameraman is not visible. This made it possible, for example, to create video of a slow rowing trip along a river. The shooting distance is also very important for the final result, so that trees, animals, or other objects appear as close to their natural size as possible to enable immersion.

VR dome optimization work should also take the audio system into account. It is important to ensure that video sound is reproduced at an appropriate level and with a suitable frequency response, and that audio channels are routed correctly. External noise sources outside the dome space should be minimized whenever possible to preserve immersion.

Picture 14. Video production on the river (ISLE Art Industries).

Special techniques for moving videos

Camera movement should always have clear and justified motivation in virtual natural environments. Based on experiences gained during the project, camera movement in nature-based interventions should be very slow to avoid inducing motion sickness or nausea, particularly when VR dome or VR headsets are used. To support an immersive experience, the speed of movement should correspond to natural, slow human motion, such as walking in nature, or slow rowing or paddling on water. When viewed on smaller screens, camera movement was found less likely to cause discomfort, and the sense of immersion can be further enhanced by synchronising physical activity—such as cycling on a stationary exercise bike—with the movement of the image, allowing visual motion to align with bodily movement (see, e.g. medeka.fi).

When imitating a peaceful motion in nature, the most suitable techniques to shoot slow movement were by using 360-degree cameras with a cable technique or attached to a helmet. It is also possible to attach 360-degree cameras to a drone or a floating stationery, but the angle of view was not most suitable for imitating usual outdoor activities for the pilot groups. When producing videos for the 2D screen, it is also possible to use GoPro camera with a fluid gimbal which reduces camera shake when shooting while walking or cycling. Regardless of the filming technique, attention should be paid to the height of the camera, which should be close to the eye level of a person walking in the terrain or sitting in a boat.

Cable-cam technology is particularly well suited for filming expansive landscapes, forests, gorges, and calm transitional movements. Filming in natural environments should always be carried out with minimal disturbance. At filming locations, animal breeding seasons and feeding areas must be avoided, as cables can cause stress or pose a collision risk, especially for birds. Lightweight mounting solutions should be utilised to ensure that trees and other natural structures are not damaged. It is always advisable to agree on filming activities with the landowner and to verify the necessary filming permits in advance.

The load applied to the cable must be carefully calculated in relation to cable tension and load-bearing capacity, taking into account the camera, mounting equipment, and an adequate safety margin. From the perspective of image stability, wind is the primary challenge: the longer the cable span, the greater the induced vibration. When selecting equipment, particular attention should be paid to operational noise so as not to disturb the subject being filmed or interfere with any sound recording.

Movement captured using a cable system is visually more striking than static shots; however, in virtual nature interventions it should be employed with restraint. Slow, steady motion enhances the perception of depth in forest and landscape imagery. Because cable systems are difficult to reposition quickly in the field, filming must be carefully planned in advance with respect to lighting conditions.

Picture 15. Video production with cable camera (photo: Miika Rantala, ISLE Art Industries).

3 Enhancing the outcome of virtual nature interventions

Elisabet Bohlin, Martta Niemi and Martin Gärdemalm

Picture 16. Testing the VR headsets with care professionals (photo: Martta Niemi).

The effectiveness of virtual nature interventions relies not only on careful environmental design of the virtual natural environments and the available content selection, but also on how the intervention is introduced and guided. Of great importance as well is the design of the facilities for the intervention, furniture, and of course the design and quality of all equipment used. Optimised settings are crucial to enable the immersive virtual nature experience. In this chapter, we describe the factors and technical aspects in more detail that we have found to be important for creating a successful virtual nature experience.

3.1 Introduction of the intervention to participants

The introduction of a virtual nature intervention should be regarded as a critical element of its implementation. When virtual nature is implemented within social and health services, it is essential to clearly and appropriately articulate the background, content, and potential of virtual nature interventions. Providing both management and staff with a comprehensive overview of these interventions

supports their effective adoption and high-quality implementation in client work. Furthermore, enabling staff to experience virtual nature firsthand in a high-quality setting enhances their understanding and knowledge to integrate these interventions into their everyday professional practice.

Findings from the NATUREACH project demonstrate that client expectations can strongly influence outcomes, either enhancing or undermining the positive effects of the intervention. Managing expectations is therefore even more important than in real-life nature-based interventions, as virtual environments may easily be associated with common nature films or television programmes. Unlike such media, which are directed and edited to convey a narrative or education, virtual natural environments should be presented as experiences intended to resemble being immersed in nature by oneself, preferably using continuous recordings without disruptive cuts.

Client expectations can strongly influence outcomes.

Recommended components of introduction

The introduction to a virtual nature intervention should include clear and concrete instructions tailored to the individual client. At a minimum, the following elements should be addressed:

- **Purpose of the intervention:** The purpose of the intervention should be explained in relation to the individual client's needs and goals (e.g. recovery, stress reduction, calming, or pain management), and how the virtual nature experience is intended to support these aims.
- **Clarifying the nature of the virtual experience:** It should be clearly explained that the virtual natural environment is not a film or a television programme with a predefined storyline. Instead, it is designed to resemble being present in a natural setting, without narrative guidance or directed viewing, allowing the client to engage with the environment at their own pace.
- **Guidance for managing negative thoughts or discomfort:** Clients should be informed that negative thoughts, restlessness, or discomfort may occur during the experience. Clear guidance should be provided on how to respond, such as gently bringing attention to the breath, engaging in a brief mindfulness exercise, shifting focus to sensory aspects of the environment (sounds, light, movement), adjusting posture or gaze, pausing the experience, or ending the session early if needed.

- **How to experience a 360-degree virtual environment:** Clients should be instructed on how to engage with the 360-degree environment, including the possibility to look around freely, remain seated or still, and allow the experience to unfold without any performance demands.
- **Technical and practical information:** Basic technical details should be explained in advance, including how the equipment works, how long the session will last, how sound is used, and what to do if technical issues or physical discomfort (e.g. dizziness or nausea) occur.

3.2 Indoor settings for a successful intervention

To get the best possible experience in a virtual natural environment, it is important to ensure a comfortable and safe space when using virtual environment applications. The space in which the virtual nature intervention takes place should have the following characteristics:

The room should be as silent as possible. This is crucial. A gentle and unobtrusive soundscape is an important key characteristic of many authentic natural environments that differentiate them from urban places which often have a high level of noise pollution. Many virtual natural environments are therefore purposely designed with very delicate soundscapes with overall lower sound levels than, for example, videos made for TV or cinema. They will therefore not work as intended if the room round the viewer is not silent. It will feel like the sound level is too low, leading to a desire for the viewer to increase the sound volume, which in turn will amplify the video's background noise and thereby reduce audio quality. In practice, this means it can be a good idea to avoid rooms close to big roads with heavy traffic, rooms with loud ventilation or noisy radiators, rooms with household appliances (refrigerators, freezers), and buzzing fluorescent ceiling lights, etc. The quieter the room is the better the experience will be for the user.

The quieter the room is the better the experience will be for the user.

Good air quality, scent and temperature. Fresh air is an important key characteristic that separates authentic natural environments from indoor environments. If possible, it can be a good idea to prepare the room you will sit in before starting the intervention by opening a window and letting in fresh oxygenated air as well as letting out unwanted indoor smells. It goes without saying that this only works if the outdoor air quality is good enough. This is another reason why you should try to avoid rooms close to busy traffic or industry. For maximum viewer immersion, it is also good to think about the room temperature in relation to the virtual natural environment you want to use. For example, if you want to sit in a snowy winter setting, you can choose to ventilate the room longer than

if you plan to sit in a sunny summer environment. It is also possible to include scents, tastes and tactile sensations with the interventions by using additional equipment such as fans, heaters, scent materials or other natural elements, in order to enhance the immersive nature experience (see Chapter 4).

Appropriate lighting. *When using the VR headsets*, sitting in strong direct sunlight may not be optimal, as light can leak into the headset, leading to unwanted reflections. Sitting in a very dark room may interfere with the headset's position tracking. If the room gets too dark, the headset will show a warning message to the user. Most other lighting is totally fine. Regular ceiling lights or soft ambient lights from a window, for example, work well. *When using the screen or VR dome, cube or cylinder,* the best visual environment is created in a space that can be completely obscured from other light sources than the projectors.

Viewing Position and Furniture. *When using the VR headsets,* the choice of viewing position is a matter of personal preference, but we recommend a seated or semi-reclined viewing position. This could be in a chair, recliner, sofa etc. There are several reasons for this:

- The virtual natural environments are mostly recorded with a camera height roughly matching a seated position or slightly lower. Therefore, a seated viewing position will feel more realistic than standing up.

- Lying down flat on the bed can be uncomfortable, due to the design of the VR headset. It also limits the viewer to mostly looking up at the sky or to the sides. With that said, do not let this recommendation restrict the user experience. It can make the virtual nature intervention more immersive and less stale if you sometimes change your viewing position. You can look behind you, lay down on your back and look at the clouds in the sky, stand up briefly to stretch out your legs, etc. Just make sure not to walk around the room, as this can pose a safety risk.

- A recliner can be very comfortable and relaxing, a sofa makes it easier to alternate between looking at the horizon and looking up at the clouds in the sky, sitting on a soft carpet on the floor can give a more grounded experience, and sitting on a rotating office chair makes it super-easy to look in different directions. When using a bed, it is often best to make it as upright as possible by adjusting the angle of the bed or adding pillows.

Picture 17. Virtual nature intervention with armchair (photo: Catharina Norberg).

When using a VR dome, the choice of viewing position is a matter of personal preference and can vary from seated or semi-reclined to full-reclined position, due to the 180-degree view. *With screens or a VR cube / cylinder,* the full-reclined viewing position is not recommended, as the ceiling lacks the video projection compared to the VR dome. In the next chapter, we will describe the features and user experiences of various VR devices in more detail.

When it comes to selecting the furniture, we encourage experimentation to see what works best for the specific user groups.

4 VR equipment

Vaiva Stanisauskaite, Joni-Roy Piispanen, Martta Niemi and Martin Gärdemalm

This chapter provides guidance on the decision-making process when deciding which VR equipment to choose for your specific use case and needs. VR equipment comes with various specifications, which need to be considered before making a purchase decision. These guidelines and recommendations include assessments of client needs, evaluating technical specifications, considering quality, comfort, safety and usability aspects, assessing software and content options, managing costs, and ensuring adequate support and warranty provisions. Our aim is to empower individuals and organisations to make informed decisions when purchasing VR equipment, thereby increasing the benefits from the virtual nature interventions within social and health care, but also among other client groups.

4.1 Background

VR technology can provide realistic nature experiences through immersive multimodal environments. Virtual nature interventions leverage VR technology to transport individuals to digitally created environments that closely resemble natural landscapes. By using VR and interactive elements, users can engage with and explore these environments, providing a multisensory experience that mimics the sights and sounds that can be complemented with other sensations like scents, tastes and tactile sensations associated with the natural environments.

Previous research shows that immersive virtual experiences have more effective restorative effects, with the large variabilities (see, e.g. Spano et al. 2023).

As being in a virtual nature is very different from, for example, gaming or experiencing augmented reality in virtual environments (see section 2.1), the devices must also be optimized to provide as natural as possible visual, auditory and other sensory experiences. Immersion level can be increased with VR headsets and other 180-degree or 360-degree VR screens like domes, cubes or cylinders, where virtual natural environments often produce stronger effects than videos via 2D screen. However, the process of purchasing VR equipment for nature interventions can be complex and challenging, considering the special needs and wide range of options with remarkable price differences available on the market.

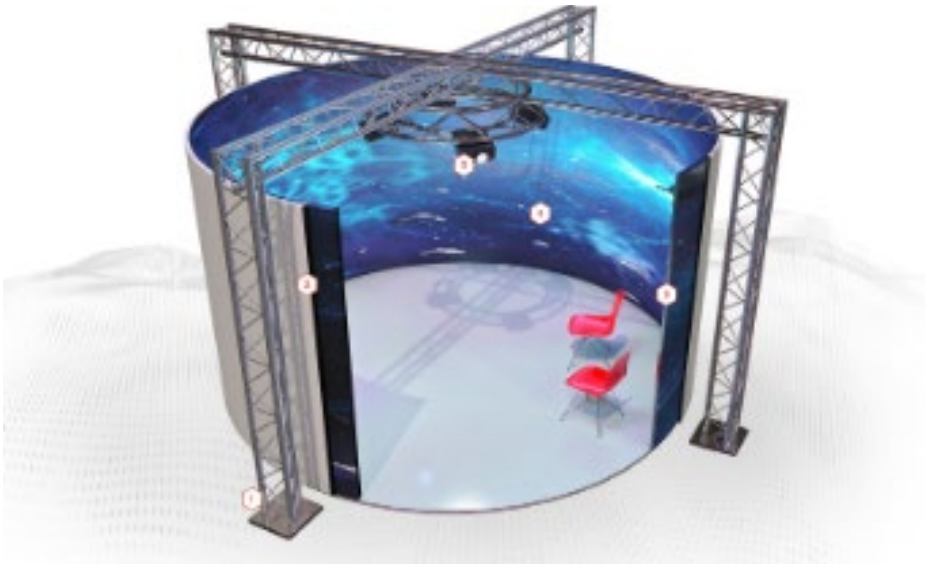
The subsequent paragraphs aim to support the steps involved in selecting appropriate VR equipment to effectively implement virtual nature interventions considering the special needs of vulnerable client groups. The guidelines are based on our experience of the procurement process of Virtual Reality headsets, the Virtual Reality dome, screens, and other supportive equipment and accessories for the NATUREACH project.

4.2 Client needs assessment

Before purchasing VR equipment for virtual nature interventions, conducting a thorough client needs assessment is essential. The assessment helps identify the specific requirements and preferences of social and health care clients, ensuring that the selected VR equipment aligns with their needs. It is important to consider age, physical and cognitive abilities, as well as visual or hearing impairments. This chapter is specifically designed to cater to the needs of individuals and organisations involved in the procurement and implementation of virtual reality equipment for social and health care clients.

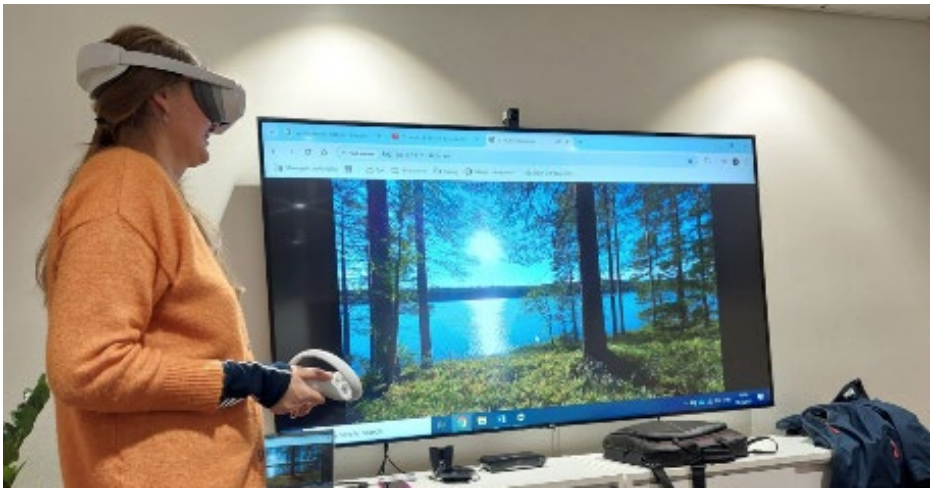
Considering physical restrictions and special needs

In social and health care, many client groups have physical and cognitive disabilities that need to be considered when selecting the equipment and evaluating the need for supportive accessories. The following comparison of different types of VR equipment is made in accordance with the experiences in the NATUREACH project.



Picture 18. Ecample of a bigger VR cylinder (Polidomes.com).

Picture 19. Example of a VR cube (igloovision.com).



Picture 20. Example of a screen combined with VR headset (photo: Elisabet Bohlin).

Equipment	Pros	Cons	Cost estimates*
VR headsets	• 360-degree projection supporting immersion • Portable device • Large selection of suitable models available	• Physical contact with equipment • Needs charging • Needs updates	From 300 €
VR dome	• Projection also in the ceiling, well-suited for clients in care beds • No physical contact with equipment • Closed space supporting immersion	• Needs special expertise to buy, assembly and maintain • Needs considerable space • Not easy to move	From 40 000 €
Screens (2D plain or curved) Video projectors for white walls	• No physical contact with equipment • Easy to assembly and use • Does not need a big studio room	• Plain 2D screens do not create as good immersion compared to other VR devices	From 1000 €, bigger LED-wall screens from 10 000 €
VR cube	• No physical contact with equipment • Closed space supporting immersion	• Needs special expertise to buy, assembly and maintain • Not easy to move • Needs considerable space • Corners may disrupt immersion	Prices vary substantially between smaller, advanced or scientific/device-level immersive systems.
VR cylinder	• No physical contact with equipment • Closed space supporting immersion	• Requires special expertise to buy, assembly and maintain • Not easy to move • Needs considerable space	Prices vary substantially between smaller and bigger installations.

*The price levels are based on surveys and estimates made during the project and may vary significantly, depending on the size of the device, software, and additional services.

Table 1. Comparison of different types of VR equipment.

4.3 Virtual Reality Headsets Overview

Virtual reality headsets are a crucial component of creating immersive virtual nature interventions. They are the primary interface between the user and the virtual environment, providing visual and auditory stimuli that transport individuals into simulated natural landscapes. When selecting VR headsets for social and health care clients, several factors should be considered, including the type of headset and its specific features and capabilities.

It is important to choose the correct type of headset for the presentation of virtual natural environments. There were two types of headsets considered for the project:

- **Tethered VR headsets** require a connection to a powerful computer to deliver high-quality graphics and processing capabilities. They typically offer the most immersive and visually stunning experiences, making them suitable for more advanced and demanding applications.
- **Standalone VR headsets** are self-contained units that do not require a separate computer for operation. They offer greater portability and ease of use, making them suitable for social and health care settings where mobility and simplicity are important factors.

It is important to choose the correct type of headset

Ultimately, the choice of VR headset depends on the intended use case, client needs, and available resources. Evaluating these factors will assist in selecting the most appropriate headset to create immersive and effective virtual nature interventions for social and health care clients. For the NATUREACH project, we chose the standalone headsets, as portability and usability were priorities for our client groups. Accessibility was a primary concern in our decision-making process, and as such, we did not want our VR headsets to require a computer for operation. The options selected on the basis of usability and price were tested with care professionals from the client pilots, who assessed the various models in terms of their suitability for their clients or patients. An example of the questionnaire used in the assessment of various models is presented in Appendix 2.

It is important to note that VR technologies are developing very fast, and it is therefore necessary to check the market for the best currently available VR equipment when making a buying decision. Consequently, our suggestions for specific VR headset models will become obsolete in a few years' time. Regardless, there are certain specifications that affect decision-making regarding which VR headsets to choose, which we specify in the following sections.

Picture 21. Virtual natural environment: Seaside in winter sun (cinematography by Esa Siltaloppi).

Technical Specifications

Understanding the technical specifications of VR equipment is crucial to ensure optimal performance and user experience. There is a need to consider the following technical aspects when evaluating VR equipment options:

Display resolution: Higher resolution displays offer a sharper and more immersive visual experience.

Refresh rate: A higher refresh rate reduces motion blur and enhances the fluidity of VR experiences.

Field of view (FOV): A wider FOV provides a more expansive and realistic view of the virtual environment.

Interpupillary distance (IPD): The distance between pupils is different for each person, and as such the VR headset needs to calibrate the IPD for each user. Various VR headsets have differing options for how to adjust IPD: fixed, mechanically adjustable, software adjusted, or automatic adjustment.

Audio quality: It is better if the VR headset and software support spatial audio technology. Spatial audio simulates the directional and distance-based sound cues present in real-world environments. This allows users to perceive sounds

coming from different directions and distances, enhancing the immersion of the virtual nature experience.

Battery life: Longer battery life is desirable, especially in situations where frequent charging may not be convenient. Consider headsets with extended battery capacity to support longer VR sessions.

Setup process: Assess the ease of setting up and calibrating the VR equipment. Simplified setup processes can save time and make it easier for staff to use and operate the equipment. Also, consider whether the VR headset supports options for automatic calibration.

User interface: Evaluate the user interface of the VR equipment, including the menu navigation and controls. Intuitive interfaces reduce the learning curve and enable clients to interact with the virtual environment effortlessly.

Control scheme: There are various control schemes for VR headsets with some supporting eye tracking-based navigation, hand tracking-based navigation, auditory navigation, or controller-based navigation.

Tracking and positional sensing: VR headsets have varying numbers of cameras and sensors for tracking. Head tracking, controller tracking, and eye tracking can occur in various ways, depending on the VR headset. Make sure that your choice of VR headset supports the modes of tracking that are relevant for your use case.

Support for data collection: Some VR headsets support data collection natively, while others require custom data collection pipelines. Consider how the specific VR headset approaches eye tracking (data, accuracy and sampling rate), gaze-based interaction (data, pupil dilation and blink metrics) facial expression recognition (data, cameras and fidelity), and data storage and privacy (cloud vs. local, data granularity, and storage capacity).

Quality and comfort of VR headsets

The quality and comfort of VR headsets play a vital role in user engagement and satisfaction. There is a need to consider the following factors related to quality and comfort:

1. **Portability:** Look for lightweight and portable headsets that are easy to wear and transport, as this facilitates mobility within various settings and

among various clients. Most VR headsets come in cumbersome boxes, so it is advisable to buy separate cases if transportation is necessary.

2. **Build quality:** Evaluate the overall build quality of the VR equipment, including the materials used and the durability of the headset and controllers. Evaluate the lenses, cameras, speakers, cushions, straps, buttons and connectivity of the devices.

3. **Ergonomics:** Prioritise headsets with ergonomic designs, adjustable straps, and cushioned padding. Comfortable headsets minimise fatigue and allow for longer VR sessions. Consider the patients, whether they need special padding or straps for lying down.

4. **Weight distribution:** Consider headsets that distribute weight evenly and reduce pressure on the face and head. Lighter headsets are generally more comfortable for extended use.

5. **Controllers:** Controllers should be ergonomic and easy to hold, especially for clients with limited dexterity or physical impairments. Look for controllers with intuitive button layouts and comfortable grips to facilitate ease of use and minimise user fatigue. In the NATUREACH project, we chose a VR headset and supporting software that allowed controllerless navigation. Navigation was done via eye-tracking, which minimised the need for controllers and excessive equipment during the interventions.

6. **Use with glasses:** Make sure that you can use VR headset with spectacles. Some VR headsets have special parts for adjustment with glasses.

Examples of supportive accessories

- Clients using VR headsets in hospital beds can use "ear pillows" with the hole in the middle to avoid the pressure of the adjustment knob. An alternative is to use VR headsets models that have optional soft straps without an adjustment knob.

Pictures 22 and 23. Accessories for VR interventions (photos: sairaalatukku.com and fyndiq.fi)

Software and Content

The availability and quality of software and content are critical for engaging virtual nature interventions. Consider the following aspects related to software and content:

Content compatibility: Check your choice of VR headset for compatibility with the VR videos you plan to use, as requirements may differ, depending on whether the videos are streamed or stored locally on the device. Some headsets impose platform-specific or vendor-locked restrictions, so ensure that supported formats align with your intended applications. Depending on the processing power of the VR headset, certain videos (particularly high-resolution or high-bitrate content) may not be playable. It is therefore advised to match video resolution, frame rate, and quality settings to the device's decoding capabilities. Additional constraints may apply to video formats, codecs (e.g. H.264, H.265/HEVC, AV1), container formats, and stereoscopic layouts.

Streaming vs local playback: Streaming VR content introduces dependencies on network bandwidth, latency, and stability, which can significantly affect playback quality and user experience. Headsets may vary in their support for adaptive bitrate streaming, buffering strategies, and wireless standards (e.g. Wi-Fi 5 vs Wi-Fi 6/6E). Local playback, while reducing network dependencies, is constrained by on-device storage capacity, file system limitations, and transfer workflows. These trade-offs should be considered when planning deployments in research, training, or healthcare contexts.

Software platforms and ecosystems: VR headsets typically operate within specific software ecosystems (e.g. proprietary app stores, enterprise platforms, or OpenXR-compatible environments). Compatibility with media players, custom applications, and development frameworks (such as Unity or Unreal Engine) should be verified in advance. In enterprise and research settings, support for sideloading, device management tools, and offline operation may be critical.

Performance and playback constraints: Content performance is influenced not only by raw resolution but also by frame rate, encoding profile, and decoding efficiency. Insufficient performance may result in dropped frames, increased latency, or visual artifacts, which can negatively impact comfort and immersion. For prolonged or sensitive use cases, such as rehabilitation or training, maintaining stable playback parameters is particularly important.

Updates, maintenance, and longevity: Firmware and software updates can alter supported formats, playback behaviour, or security policies over time. It is

recommended to monitor updating cycles and test content compatibility after major system updates, especially in long-term studies or deployments. Version control of both software and content can help ensure reproducibility and consistency.

Nature-related experiences: Assess the availability of nature-related VR experiences and applications. Look for a diverse range of content that includes various natural environments and activities to cater to various client preferences.

Customisation and flexibility: Consider whether the VR software allows customisation of the virtual environment and the ability to tailor the experience to individual client needs and preferences.

Picture 24. NATUREACH project group testing VR-headsets (photo: Martta Niemi).

Examples of VR headset models available in January 2023.

- Oculus Rift S: The Oculus Rift S provides a high-resolution display, inside-out tracking, and comfortable controllers. It offers a wide range of software and content options, making it suitable for a variety of virtual nature interventions.
- HTC Vive Pro: The HTC Vive Pro delivers excellent visuals, precise tracking, and a large field of view. It offers a high-quality audio system and supports external tracking for even more accuracy. The Vive Pro is

suitable for clients who require the utmost in performance and visual fidelity.

- Valve Index: The Valve Index offers a high-resolution display, a wide field of view, and precise finger-tracking controllers. It provides exceptional tracking accuracy and is known for its immersive experience and comfort.
- Oculus Quest 2: The Oculus Quest 2 is a versatile all-in-one VR system that offers wireless freedom and the ability to connect to a PC for more demanding experiences. It provides a high-resolution display, inside-out tracking, and intuitive controllers.
- Pico 4: The Pico 4 is a lightweight, standalone VR headset with a sleek design, featuring 4K+ resolution (2160 x 2160 per eye), pancake lenses, and a wide 105-degree field of view. Powered by the Snapdragon XR2, it delivers smooth performance with up to 90Hz refresh rates, inside-out tracking, and ergonomic controllers. It offers built-in spatial audio, supports PC VR via wired or wireless connections, and runs on Pico's VR OS with access to a variety of apps and games.

Health and safety issues

VR headsets can be used by most people, but certain individuals may face challenges using VR headset comfortably or safely. Particularly children, people with medical conditions, pregnant women, those prone to motion sickness, persons with disabilities, individuals with claustrophobia, and other vulnerable groups should take care when deciding on using VR headsets. It is strongly recommended that you consult an expert before deciding on using VR headsets if you belong to or plan to use them with a vulnerable group. Below are specific guidelines for vulnerable groups that should consider carefully whether VR headsets are appropriate for their specific situation:

- **Children:** VR may affect developing vision, so it is advised that children under the age of 13 refrain from using VR headsets.
- **People with medical conditions:** Conditions like epilepsy, seizures, motion sickness, vestibular disorders or other neurological conditions may cause discomfort or exacerbate symptoms when VR headsets are in use.
- **Pregnant women:** Some research suggests potential risks to the foetus, so consulting a healthcare provider before using VR headsets is advised.

- **People prone to motion sickness:** VR experiences with rapid movements may induce discomfort due to a mismatch between visual cues and the body's vestibular system.

- **Individuals with disabilities:** Visual impairments, mobility issues, or specific eye conditions may make using VR challenging. Individuals with certain eye conditions, such as strabismus (eye misalignment), amblyopia, or significant refractive errors, may experience difficulties in focusing or perceiving depth in VR environments.

- **Those with claustrophobia:** The enclosed nature of VR experiences may exacerbate feelings of discomfort or anxiety.

Some users may also experience allergic skin reactions due to the materials used in VR headsets or due to improper cleaning of the devices. The following health and safety instructions were used in the NATUREACH project, but can also be applied with other VR headset models:

- If you notice any irritation, stop using the device immediately and consult a medical professional.

- If you start feeling dizzy or nauseous, remove the VR headset immediately and monitor your condition. Sit or lie down in a comfortable position until the symptoms subside. Consult a medical professional if necessary.

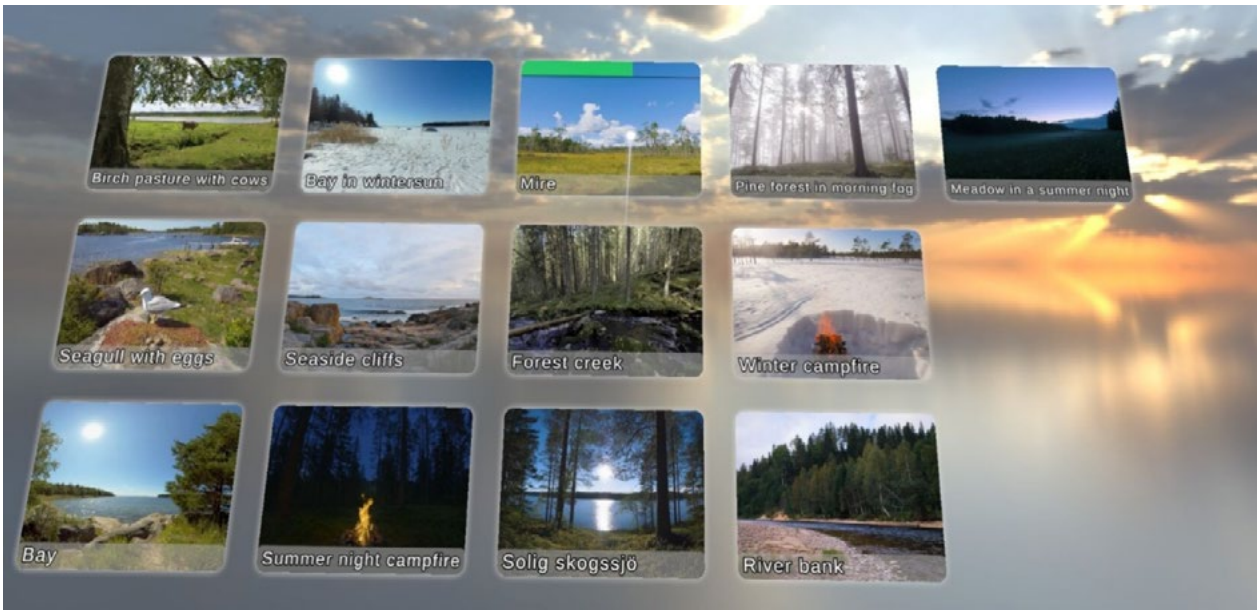
- Prolonged use of the VR headset may cause dizziness or eye fatigue. It is recommended that you take frequent breaks.

- You may be able to relieve eye strain by watching distant objects. If you feel any discomfort, stop using the device immediately.

- If the VR headset is shared among multiple users, thoroughly clean and disinfect the device between each use. Maintain personal hygiene. Wash your hands (if possible) thoroughly before and after putting the headset on.

- Do not use VR headsets while operating vehicles, heavy machinery, or performing tasks that require that attention is given to the real world.

- Always ensure a safe and open area when using the device to avoid physical harm to yourself or others.



Picture 25. NATUREACH media player with our virtual natural environments. Navigation and selection based on eye and head tracking without hand controls.

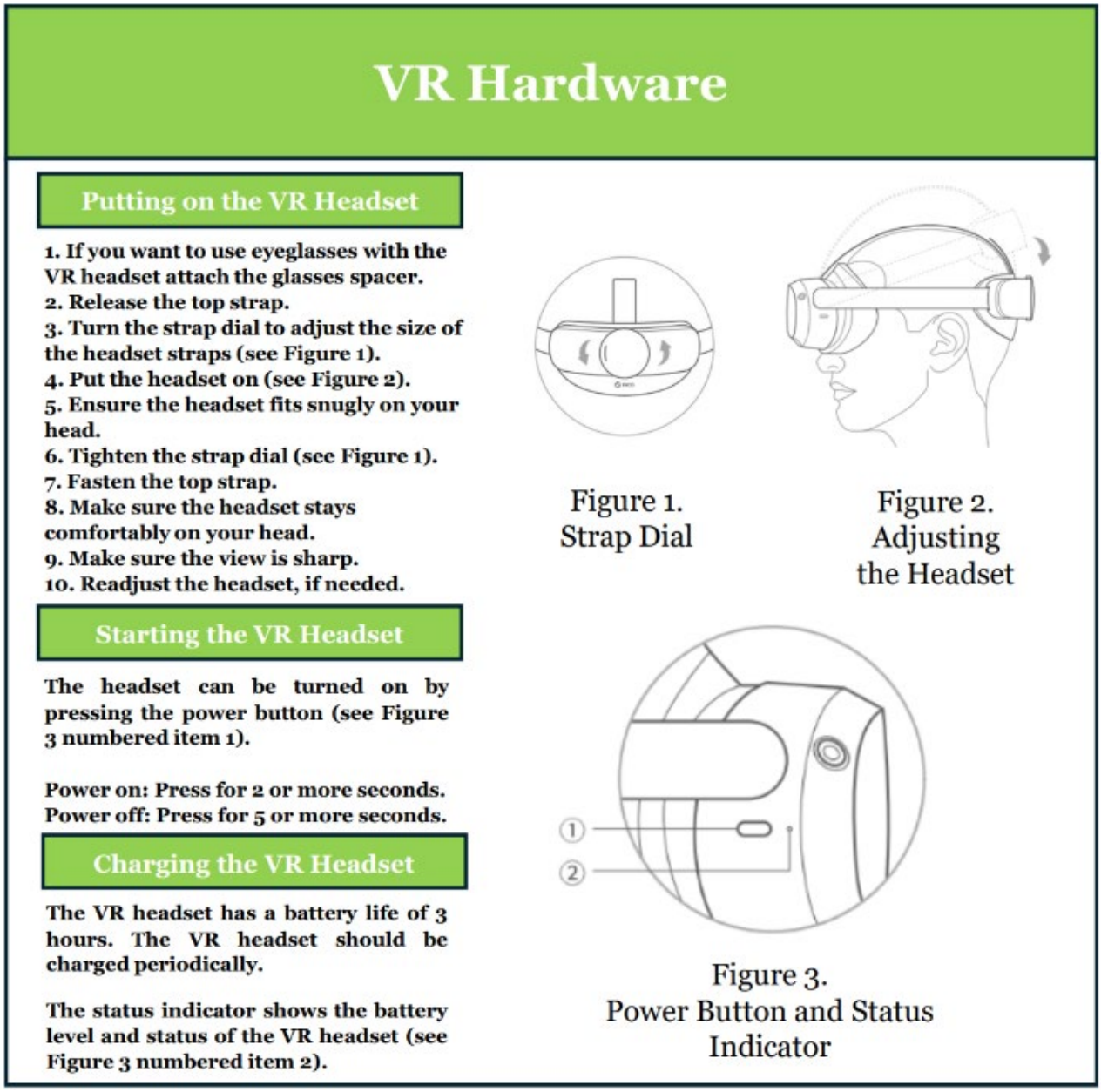
The virtual nature interventions in the NATUREACH project were intended to be used solely in stationary positions with the following instructions:

- Please be aware that for safety purposes it is always recommended that you remain stationary and preferably seated within your physical area. Moving outside this area can lead to colliding with objects, walls, furniture, or other people in your surroundings. Such movements pose a risk of physical injury, property damage, or device damage. To prevent accidents or injuries, it is important not to move your position or take steps.
- Always be aware of your surroundings and the limitations of your physical space. Avoid reaching out beyond your play area or making sudden movements that could lead to accidents.

By adhering to these guidelines and exercising caution, people can enjoy immersive VR experience. It is important to remember that safety is paramount, and one should always prioritise caution and awareness when using VR technology.

More information about safety can be found from the respective company's manuals and website: https://www.picoxr.com/sg/safety-center

User manuals and quick guides created in the NATUREACH project: https://www.slu.se/en/natureach



Picture 26. Example of a quick guide from the NATUREACH project (www.slu.se/en/natureach).

4.4 Virtual Reality Dome

VR domes offer a distinct immersive experience for virtual natural environments. Compared to VR headsets, they allow for more social and spatially aware interactions with nature. VR domes support freeform immersion into the natural elements within the scene. With no restrictions on physical ability, VR domes offer the most accessible solution to providing immersive virtual nature experiences. VR domes facilitate interaction regardless of bodily stance. Users and patients can be in a hospital bed, wheelchair, lying or sitting on the floor, standing, crouched, kneeling, on a chair or sitting on any other surface while experiencing the environment. This is especially helpful when utilising virtual natural environments with persons who have physical restrictions.

However, certain factors should be considered when deciding whether a VR dome is suitable for your specific context. The primary factor affecting VR dome adoption is the high upfront cost of the equipment compared to VR headsets or smaller screens. Relatedly, the costs of upkeep, maintenance, and technical support need to be considered. VR domes are still a novel and niche piece of technological equipment. Thus, the technical expertise required to run, repair, and maintain the VR dome represents an important factor. Based on our experience, it is advised to have an in-house team of technical experts that can operate and support the use of a VR dome. Once the necessary technical expertise is in place, the process of acquiring the equipment can proceed. Below, we discuss the steps in purchasing a VR dome as a part of the NATUREACH project.

Picture 27. VR dome in Eskoo (photo: Vaiva Stanisauskaite).

The process of purchasing virtual reality dome

The process of purchasing a virtual reality dome began with conducting thorough research. This involved searching online for information about virtual reality domes and exploring their features and benefits. Once enough information was gathered, various companies that specialise in selling virtual reality domes were contacted via email to inquire about pricing details and obtain additional specifications regarding the VR dome models.

In NATUREACH project, the intended users of the dome have been included in the planning process already at the preliminary investigation stage, in order to gather specific requirements regarding the preferred type and size of the dome. Based on this information, a selection of potential suppliers was made. Initially, various equipment types and shapes were considered, such as cubes, cylinders, and others.

After receiving preliminary price offers and gaining a better understanding of the required dome specifications, the list of potential suppliers was narrowed down. To address any inquiries and discuss product specifications and customisation options, online meetings were arranged with each of the vendors. Following the discussions with the vendors regarding the product and the client organisation's needs, a formal call for tenders was made, including the price, technical details with customisation options, installation service, technical support, shipping costs, and warrants, as well as other associated services and fees.

Based on the experiences gained in the project, the following general notions can be considered when purchasing a 360-projection dome:

1. **Size and space:** Determine the available space where you plan to install the 360-projection dome. Measure the dimensions and ceiling height to ensure it will fit comfortably. The most critical measurement is usually the ceiling height, which defines the size of the whole structure. Consider the dome's diameter and height to accommodate the desired number of viewers. The selection of domes is very limited, so the bigger room you have for the dome, the more dome choices you have. This was our case, the room ceiling was quite low, so we had to go with the tilted dome option versus regular dome shape.

2. **Budget:** Set a budget for your 360 projection dome purchase. Prices can vary depending on the size, features, and quality of the dome (including value added tax, if applicable). Consider your requirements and prioritise features that align with your budget.

3. **Customs and import regulations:** If you're purchasing a 360 projection dome from a seller outside Europe, you need to consider customs and

import regulations. Research the potential import duties, taxes, and any other requirements imposed by your country's customs authority. Identify the country of origin for the imported dome. If the purchase is made within the European Union, no import tax is required.

4. **Projection System:** Evaluate the quality and capabilities of the projection system. Look for a dome that offers higher-resolution projection with vibrant colours and sharp imagery. Consider the brightness of the projector to ensure optimal visibility in various lighting conditions. Consider which type of projector you want to choose (laser projector, lamp projector or led projector), as they all have some advantages and disadvantages. Please note that various companies offer different types of projectors.

5. **Dome material and construction:** Consider the quality and durability of the dome material. It should be sturdy enough to withstand regular use and transportation if necessary. Look for a dome with a smooth surface to ensure proper projection without distortions.

6. **Immersive experience:** Assess the level of immersion provided by the dome. Consider features such as a seamless projection surface, curved or dome-shaped design, and proper alignment of projectors to create a truly immersive experience for the viewers.

7. **Viewing angles:** Check the viewing angles offered by the dome. Ensure that the projection system provides a wide field of view for all viewers, regardless of their position inside the dome. It should allow for an immersive and seamless visual experience from any angle.

8. **Audio system:** Evaluate the audio capabilities of the 360-projection dome. Look for built-in speakers or consider integrating a separate audio system to provide high-quality surround sound. The audio system should be able to deliver immersive and synchronised sound throughout the dome. Make sure the audio of your videos is compatible with the dome. Check what type of sound system the dome has; for example, a stereo or 5.1 sound system.

9. **Content compatibility:** Ensure that the 360-projection dome is compatible with the content you plan to display. Check for compatibility with popular media formats and content creation tools. Additionally, consider the ease of content integration and management within the dome.

10. **Installation and maintenance:** Assess the installation requirements of the dome. Some domes may require professional installation, whilst

others may offer user-friendly setup options. Consider the long-term maintenance needs, including access for projector maintenance and potential upgrades. Evaluating the price and arrangements for delivery and installation services. It is important to clarify whether a supervisor will be present for manual installation.

11. **Location of the seller and the shipping costs:** The location of the seller can impact shipping costs, especially if you're purchasing a large and heavy item like a 360-projection dome. Buying from a seller located closer to your region or country may result in lower shipping fees or faster delivery times.

12. **Local support and warranty**: Purchasing from a seller located closer to your region can provide easier access to local support and warranty services. If you encounter any issues or require assistance, having a local seller can make it more convenient to get help, whether this concerns technical support or warranty-related inquiries. Consider the following:

    a. Manufacturer's warranty: Check if the dome comes with a manufacturer's warranty that covers any defects in materials or workmanship. This warranty typically ensures that the product will function as intended and provides coverage for a specified period after purchase.

    b. Performance guarantee: Look for guarantees related to the dome's performance and functionality. This could include assurances that the dome will provide an immersive VR experience, with accurate tracking, high-resolution visuals, and reliable audio.

    c. Durability and maintenance: Consider warranties that cover the durability and maintenance of the dome. It is essential to ensure that the materials used are of high quality and can withstand regular use. Look for guarantees against issues like structural damage, material degradation, or malfunctioning components.

    d. Customer support: Evaluate the level of customer support provided by the manufacturer or supplier. A comprehensive warranty should include access to technical assistance, troubleshooting, and replacement or repair services if needed. Quick and responsive support can be crucial for resolving any issues that may arise.

13. **Service availability:** Check if the seller provides installation or setup services. If they do, consider whether those services are available in your

location. Buying from a local seller may increase the likelihood of having access to installation and setup assistance if you need it.

14. **After-sales support:** Consider the availability and accessibility of after-sales support from the seller. This includes factors such as response time to inquiries, availability of spare parts, and their ability to help with any maintenance or technical issues that may arise in the future.

15. **Easiness to upgrade:** Evaluate how simple it is to update hardware and software (modular components, support for future tech, clear upgrade paths).

Considering these factors will help you make an informed decision when buying a 360-projection dome that best suits your needs and provides an immersive and captivating visual experience.

Picture 28. Grazing lambs in 360-video production for VR dome (photo: ISLE Art Industries).

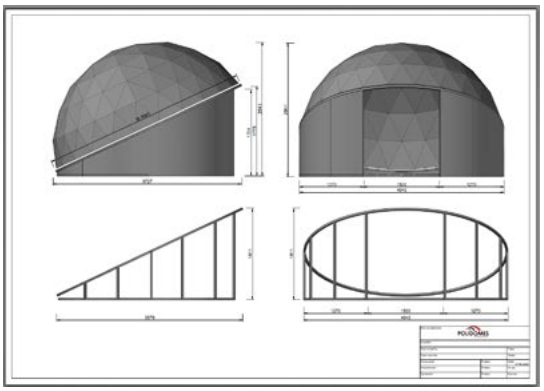
Buying a virtual reality dome: Our experiences

The first step in our purchase process was to do extensive research, considering not only the limited space for the dome structure, but also the special needs of the clients at Eskoo in Finland's Wellbeing Services County of South Ostrobothnia. The aim was to offer an immersive virtual nature experience also to the most vulnerable clients using care beds, requiring that at least part of the view is also reflected in the studio ceiling/up. Because the care bed is quite large (2.1 m x 0,9 m), the dome must be large enough to offer at least 180-degree views to the client.

Final dome specifications were 4M diameter dome with aluminium structure and cover. Projection equipment included Media server Quadro, Nest map Auto calibration protector software, four lenses for projectors, three video projectors WXGA, 2000 ansi, 20000h, Lightness of the screen more than 150lx, resolution of to 3K combined, and a 5.1. audio system.

From initial research and design through production and on-site assembly at Eskoo, the production team tailored every aspect of this dome model to meet the unique therapeutic and sensory needs of its users. Rather than using an off-the-shelf structure, Polidomes engineered and built this dome to be both functional and user-friendly for people with mobility limitations.

Picture 29. The 3D illustration of Eskoo's dome (Polidomes International).



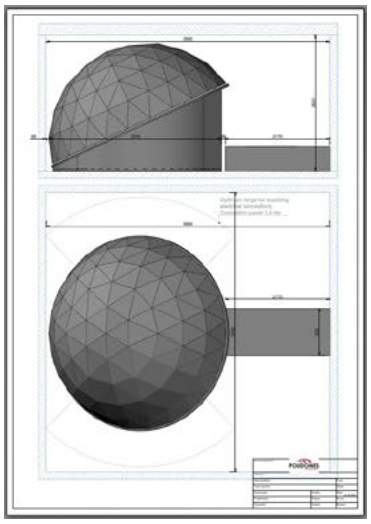


Figure 2. The exact 3D model of the dome with the dimensions from side and front

Figure 3. The exact 3D model with dimensions from top and side

Picture 30. Fine-tuning the image in Eskoo's dome (photo: Janiv Oskár).

More information about Eskoo's dome with process pictures is described in Appendix 3 and the supplier companies website: https://polidomes.com/projects/medical-dome-for-people-with-limited-mobility/

4.5 Screens and video projectors with white walls

The selection of screens or video projectors should be based on the evaluation of technical, functional, and operational requirements in order to ensure that the chosen solution delivers the required visual performance, reliability, ease of use and durability in the intended use. This includes the purpose for immersive virtual nature experiences, studio room size, viewing distance, and duration of use. Also, ambient light levels, ceiling height, available space, and acoustic constraints should be considered, as they directly influence the choice of technology (direct-view screens vs projection).

The required image size and resolution should be defined in relation to viewing distance and content. Immersive environments often require higher pixel

density to maintain image clarity at close viewing distances. For projection systems, achievable image size must be evaluated in relation to throw distance and lens options, while for screens, panel size, modularity, and bezel visibility are key issues to consider. Operational reliability and expected lifespan are important, especially for continuous use in social and health care units. In projectors, the light source (e.g. laser vs lamp) and ease of service are also good to consider before purchase.

In the NATUREACH project, a 2D screen was selected for the elderly care unit in Övertorneå in Sweden, due to the size of the studio room and the desire for more people to be able to participate in the intervention at the same time as well as discuss the content together. At Eskoo in Finland, an additional studio room was implemented by utilising two video projectors with white walls, enabling several client groups to take advantage of the virtual natural environments produced in the project. In both units, the equipment selected is considered suitable for the room size and of high quality.

4.6 VR cubes and cylinders

As the selection of the domes were limited, we also considered the other types of immersive screens/environments. The following models were assessed as suitable for virtual nature interventions:

The following models were assessed as suitable for virtual nature interventions

- GeoDome Portal/GeoDome Panorama (The Elumenati): The GeoDome Portal and GeoDome Panorama are prefabricated geodesic dome systems designed for immersive group experiences. They use a hemispherical projection surface to deliver 180-degree – 360-degree visual content, which is commonly applied in exhibitions, education, and events.
- VR Cube (e.g. from Igloo Vision): A VR Cube is a multi-wall immersive environment where images are projected onto several flat surfaces, typically forming a cube or partial cube. This setup allows users to experience surround visuals without wearing head-mounted displays. An example of a VR cube in Finland: https://www.luke.fi/en/research/research-infrastructures/virtulab-research-on-virtual-nature
- 5-Metre Cylinder (e.g. from Igloo Vision): The 5-metre cylindrical immersive screen from Igloo Vision offers a wraparound projection surface that creates a strong sense of visual continuity and scale. Cylindrical environments work well for panoramic content and group presentations.

4.7 Equipment and accessories for multi-sensory interventions

To enhance immersive experience, audio-visual sensations can be combined with scents, tastes and tactile sensations. The equipment and accessories suitable for multi-sensory virtual nature interventions will be presented in more detail in the following chapters.

OVR in virtual nature interventions

Olfaction is our first and the most primitive sense and scents are associated with multiple well-being domains. Scents like lavender, eucalyptus, pine or ocean breeze have been commonly used to calm the nervous system, e.g. in anxiety or relaxation therapy. Also, everyday life scents like coffee, bread, soap or grass can reinvigorate long-term memories of people with dementia.

Scents like lavender, eucalyptus, pine or ocean breeze have been commonly used to calm the nervous system . . .

Virtual reality is increasingly exploring multisensory experiences, and adding scents can significantly enhance immersion, emotional response and support memories. One way to include scents in the virtual nature experience is to bring authentic natural elements suitable for the environment into the intervention, such as e.g. flowers, moss, tree leaves, or berries. However, this requires that the natural elements are fresh and easily available at just the right time, which can pose challenges in terms of seasonal variations and the availability and preservation of the nature elements. In addition, allergies and hypersensitivity can cause restrictions for the use of nature elements. In health care, hygiene criteria may also prevent natural elements from being brought indoors.

One possibility is to utilise artificial nature scents by using olfactory virtual reality (OVR). Typical scent delivery methods in OVR are wearable scent devices posing small cartridges near the nose, directional scent emitters synced with head tracking, and room-based scent diffusion in VR domes or immersive VR studio rooms.

Several companies have developed technologies to bring scents into VR, each with different approaches, strengths, and target applications, for example in education, simulation, marketing and gaming. Suitable devices for virtual nature interventions were mapped as a part of the NATUREACH project. Olfy, Olorama, Scentient, and OVR Technology were companies that all address scent in VR, made for different kinds of use. Olfy is closest to events and marketing. Its devices are easy to set up and good for filling a room with a scent, but they are not ideal when scents need to change quickly or be different for each user. Olorama is built for professional installations like museums, cinemas, and VR venues. It provides better timing and control of scents, but it also requires more

Pictures 31 and 32. OVR device in test use (photos: Martta Niemi).

space, planning, ventilation and maintenance. Scentient focuses on wearable devices that sit close to the user's nose. This makes scents appear faster and more precise, which works well for training or safety simulations, though the system is less proven at large scale.

For virtual nature interventions, it needs to be checked carefully that the product fits all user setups. In NATUREACH, the most suitable device was Scentient, because it is a stand-alone device placed near the nose and fitting the multi-user setups, can be used in the VR dome, and does not add any additional weight to the VR headset.

According to our trials within the project, the scent must be used sparingly and precisely controlled to avoid an overly strong or non-natural scent delivery that may disturb immersion. It would also be good to have more options in terms of the quality and quantity of available scents, so that they could be widely applied to virtual nature.

Scientific breakthroughs have also been made in the production of artificial scents, which may also be utilised in virtual nature interventions in the future. In the Finnish study, authentic scents were measured by using an electronic nose that mimic the human sense of smell, classified using machine learning techniques and finally recreated for a demonstration in virtual reality (https://www.tuni.fi/en/news/scents-are-coming-virtual-reality).

Tactile sensations and tastes in virtual nature interventions

One way to include tactile sensations to virtual nature interventions is to add a fan or a heater to virtual natural environments that have visual and auditive wind effects or sunshine. Regarding the features of the virtual natural environment and the viewer's location, the immersive sense of place can be enhanced also

by bringing some tactile nature elements to be touched with hands during the interventions (e.g. branches, leaves, cones, stones, snow etc.) or felt under the feet (e.g. moss or sand).

In many cases, linking taste perception to interventions is challenging in relation to the content, guidelines and restrictions within social and health services. However, with some specific natural environments, it is possible to add taste sensations to enhance the immersive experience in case suitable, fresh and safe berries, fruit or plants are available for the intervention. With flavours, special attention should be paid to the client's wishes, preferences, allergies and any other constraints.

Due to the sense of taste is strongly linked to scent sensations, it is easier and more homogeneous to reinforce immersion by adding scents appropriate to the intervention.

Picture 33. Apples as multisensory nature elements (photo: Martta Niemi).

Picture 34. Gateway to nature (photo: Monika Norberg).

5 Conclusions: implemention outcomes, user experiences and lessons learned

Elisabet Bohlin, Martta Niemi and Ann Dolling

There is not only one right way to experience the well-being benefits of virtual nature, but specific ways exist to make them possible. This handbook is grounded in the practical experiences, experiments, and lessons learned during the NATUREACH project. Through the co-design and piloting of virtual nature interventions with diverse client groups, it was shown that carefully produced and thoughtfully implemented virtual natural environments can support well-being, recovery, and moments of restoration in social and health care contexts. Our work highlights the importance of quality in environmental design, multisensory elements, appropriate technology, and sensitive facilitation. Whilst virtual nature is not a substitute for real nature, it offers a valuable and inclusive way to bring nature-based benefits to those who otherwise have limited access to outdoor experiences.

Production of virtual nature interventions

The NATUREACH project involved extensive work to optimise the production of high-quality environments for virtual nature interventions. Effective production requires a combination of knowledge about health-promoting and restorative environmental qualities, based on research and established practice, together with clearly defined goals for the intervention and an understanding of participants' needs and preferences. Through the project, substantial practical knowledge and experience were gained regarding the production of restorative virtual environments, particularly for immersive 360-degree settings such as VR-glasses and domes.

Some production lessons include the importance of incorporating natural movement, such as waves, flowing water, or wind in foliage, while avoiding overly intense or disturbing motion. Filming should allow sufficient flexibility, as the material is preferably not heavily edited; multiple recordings are often needed to allow selection among takes and to avoid disturbances such as insects or sudden weather changes. It is also recommended to film in 360-degrees initially, even when the final environment is intended for a smaller dome, as this allows greater flexibility in post-production. However, if 360-degree videos were to be converted for viewing on individual 2D screens, the visual quality would likely be reduced and the aesthetic experience compromised, since the environments are selected and composed specifically to function in a fully immersive 360-degree format.

With the rapid development of artificial intelligence, many of the challenges of capturing real nature can be replaced by artificially created but real-looking videos. However, in this project, we wanted to capture a piece of authentic nature for our clients, even if it did require more effort. At the beginning of the project, we compiled a highly extensive list of various potential environments to be selected for production within the resources available. For example, there was a lot of discussion about filming the Northern Lights, but capturing them in the right place at the right time with a camera that works in demanding conditions was a challenge we did not take on this time. A powerful thunderstorm in the outer archipelago was also left for future productions.

» We wanted to capture a piece of authentic nature for our clients, even if it did require more effort.

Alongside technological expertise, knowledge of local nature is needed to find the best filming locations for each purpose. Even practical skills may be required when filming a burning campfire without adding logs in between, or when steadily rowing a camera boat along the river or using cable technology in the forest. When animals are included in virtual natural environments, it is advisable to reserve two or three times as much time for filming, as animals usually behave quite spontaneously and there may be more surprises and new takes. It is particularly important to consider carefully including people in the filmed environments, as the presence of people does not necessarily contribute to well-being, even though it was tried in some farm videos based on particular wishes.

Picture 35. Virtual natural environment: Summer night campfire (Cinematography Martin Gärdemalm).

Various ways to experience different kinds of environments

Experiences gained among our versatile groups of clients and professionals have taught us that though individual preferences may have a great variation regarding the content, devices and even the level of social interaction during the intervention, the positive impact of being in a virtual nature can be commonly shared. Overall, the virtual natural environments received very positive responses from the pilot groups. Users described the experiences as stress-reducing or energising and noted that different kinds of environments were better suited to varying moods and states of well-being. Many participants also expressed high satisfaction with the quality of the virtual natural environments. At the same time, there were considerable individual differences in preferences. Users commented that some environments felt particularly calm and restorative, while others evoked positive childhood memories, which strongly influenced their choices. Many users preferred environments near water, such as riverbanks or seashores, while others favoured open landscapes with long views, such as mires. The preconception that sunny environments are the most preferable was not generalisable, when, e.g. many Finnish users in particular preferred grey and windy seaside cliffs. Some users appreciated more intimate settings, such as a

meadow on a summer night, or environments with movement; e.g. a bird in motion. At Eskoo, clear differences were observed between clients: those in need of relaxation benefited more from calm and low-stimulus environments, whereas clients in need of activation preferred more lively environments – particularly those including animals or movement in the environment, such as rowing a boat along the river. It was also noted that virtual nature allows to "change seasons" while sitting by a winter campfire in the middle of summer. Many people live in areas where it is not possible to light a fire in the backyard, so even in this way virtual nature provided new opportunities.

Many felt that the weather in the virtual environment had a direct impact on the physical experience, making it genuinely cold on a windy beach or in a wintry environment, and prompting them to add blankets. For some, the soundscape was the most important element and they could also blend into the soundscape by closing their eyes for part of the intervention. Some also mentioned falling asleep during the nature intervention and waking up feeling very refreshed. For many participants, it was important to experience virtual nature alone in complete peace; whilst for some, sharing the experience with a caregiver was an important part of the intervention if using a dome or a 2D screen that enables more social interaction. Each device type has its own specific features that need to be considered in accordance with the user groups.

VR headsets: In four of our client groups – the patients in palliative medicine, eating disorder outpatient clinic and with diabetes type 2, and clients in elderly care – VR headsets were the main intervention format. Overall, they functioned well and most users were satisfied with the experience. However, some users encountered technical difficulties, which could likely have been reduced through guidance and a more thorough introduction. Most participants experienced the audiovisual quality positively, though a few had difficulties adjusting the sound. The overall impression in using virtual nature via VR headsets has been positive, and one thing learned is that we do not need to be afraid of testing VR headsets with older persons. According to the feedback from the clients, being in a virtual nature with VR headsets have enabled the feeling of "being away" helped them recover or reduce anxiety. Many have experienced a sense of place and felt that places in virtual nature may have become their familiar places to return to.

» Being in a virtual nature with VR headsets have enabled the feeling of "being away" helped them recover or reduce anxiety

Screens: In one client group at an elderly care facility, virtual nature films were also presented on 2D screens. This format provided an easy-to-use and familiar way of accessing virtual nature, particularly for users who were not comfortable with immersive VR technology. Whilst the level of immersion was lower compared to VR-based solutions, 2D-screen viewing still enabled activating, calm and engaging nature experiences.

The Dome*:* For clients with severe developmental disabilities at Eskoo, the virtual nature interventions in the Dome have worked well. This is largely due to its accessibility and ease of use: the Dome studio was located in the immediate vicinity of the units and clients could enter the room together with the care professional, either by walking or using a wheelchair or care bed, and immediately sit or lie down to enjoy the virtual nature experience. A staff member is always present and can easily change the environment when needed. In contrast, virtual reality headsets required more handling to fit properly and to select content, and several clients experienced the headsets as heavy and uncomfortable to wear. Over time, the virtual nature experiences in the Dome have become a natural part of daily life at Eskoo and are highly appreciated by the clients, but also the staff members. The Dome has expanded the everyday lives of the clients in a positive way, and it has become a place for relaxation and interaction. For this client group, it has been important to offer a large variation of environments and activity levels, corresponding to the diversity of individual needs from stimulation to a possibility for calm and relaxation. For some clients, the Dome with virtual natural environments has been the only place where they can completely relax during the day.

All these positive experiences of our clients participating in the project have reinforced our belief that virtual nature has a legitimate place in supporting the care and well-being of vulnerable people, but also all others with temporary or permanent restrictions on access to authentic nature. We hope that the knowledge shared in this handbook inspires and encourages further development, adaptation, and responsible use of virtual nature interventions in various fields and practices

Picture 36. A foggy winter day (photo: Monika Norberg).

Picture 37. NATUREACH project group at workshop in Vaasa, October 2023.

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Appendices

Appendix 1: Example of mapping the preferences of clients and staff

- Location: Should the film be shot in a specific place?
    - If YES, what is the place/environment like and where is it located?
    - If NO, which kind of natural environments evokes the most positive feelings?
- What is your preferred season?
  1) spring,
  2) summer,
  3) autumn,
  4) winter,
  5) all seasons
- What is your preferred weather?
  1) cloudy,
  2) variable cloudiness,
  3) clear/sunny,
  4) does not matter
- What is your preferred time of the day?
  1) morning,
  2) daytime,
  3) evening,
  4) night,
  5) does not matter
- Would you like to see animals in the video? If yes, which kind of animals?
- What is the desired total length of each video? (e.g. 15–30 min)
- Other requests regarding content and form? What is the most important thing to consider in the virtual nature video?

Appendix 2: Questionnaire for VR headset user evaluation

VR device testing

Name and organisation: _____

VR-glasses in test: Model 1 ☐ Model 2 ☐ Model 3 ☐

Your evaluation:

Give your points from 1=very poor to 5=excellent	1	2	3	4	5
1 How did the VR-glasses size fit to your head?	☐	☐	☐	☐	☐
2 Did the glasses feel comfortable?	☐	☐	☐	☐	☐
3 How was the weight of the glasses?	☐	☐	☐	☐	☐
4 How was the video quality?	☐	☐	☐	☐	☐
5 How was the audio quality?	☐	☐	☐	☐	☐
6 Could you recommend this model to your clients?	☐	☐	☐	☐	☐
7 Could you recommend this model to your staff?	☐	☐	☐	☐	☐

Other comments (e.g. if you wear glasses inside the VR-glasses): _____

_____

_____

_____

THANK YOU FOR YOUR FEEDBACK!

Appendix 3. Building a virtual reality dome guide

These were the basic steps in building the Dome in Eskoo:

1. Design the dome: Plan the size and shape of your dome. Consider the space where it will be installed and the projection system you'll be using.
2. Prepare the room: If you are using LED projectors, ensure the room is dark. Use the blackout curtains to cover the windows. You can get some comfortable chairs to put inside the dome. Ensure the power outlet needed for the equipment.
3. Organise all your parts: Have a clear plan, and the order of the various steps. Check the dome construction map. Map where the dome parts should go: You start by working from outside the dome, moving towards the middle – the middle parts are the highest, and installing them requires the use of a ladder.
4. Assemble the base: Begin by assembling the base of the dome. Connect the metal parts to create a stable foundation.
5. Create the dome structure: Build the dome structure by connecting the pipes in the desired shape. Ensure all joints are securely connected. You need to use bolts, nuts and washers for metal tubing.

Picture 38. The completed dome structure looks like this (photo: Martta Niemi).

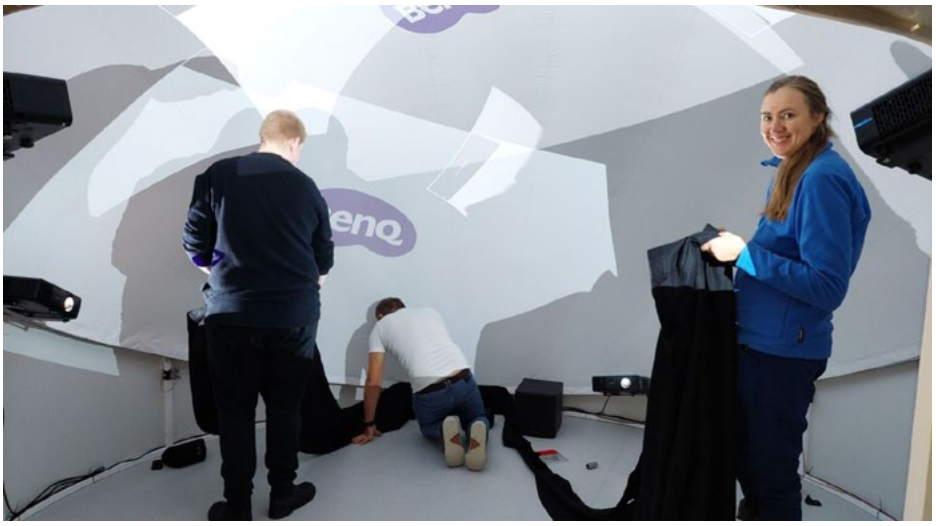
6. Attach the dome material/fabric: Once the frame is complete, carefully attach the dome outside the layer. The assembly of the covers and the dome screen involve a specific process. The dome screen is to be covered by two layers: an outer and inner cover. First, the dome is enclosed with the outer cover. Additionally, the sides of the dome are draped with extra fabric. This extra fabric serves the purpose of enhancing the client's

comfort and helping them focus more effectively on the dome screen. The outer layer of the dome is attached using the zip ties. After the two external covers are attached, the hole for the fan is prepared. The fan is needed for the screen tensioning: the airflow generated by the fan creates tension on a lightweight or flexible screen material, ensuring it remains smooth and taut for optimal projection quality.

Picture 39. Attaching the dome outside fabric (photo Martta Niemi).

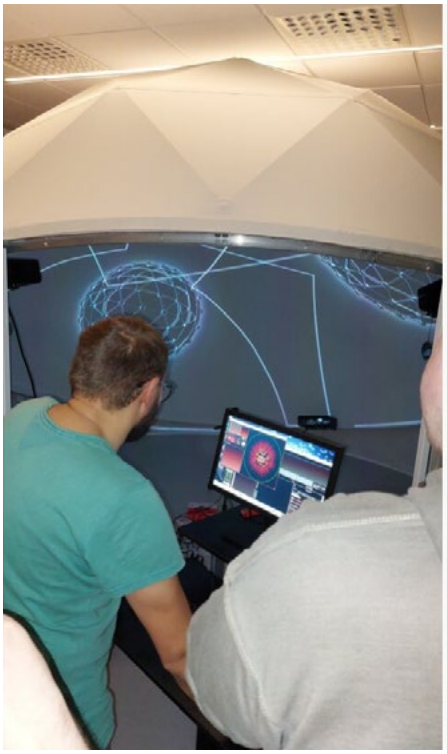
Picture 40. Dome air pressure system (photo Vaiva Stanisauskaite).

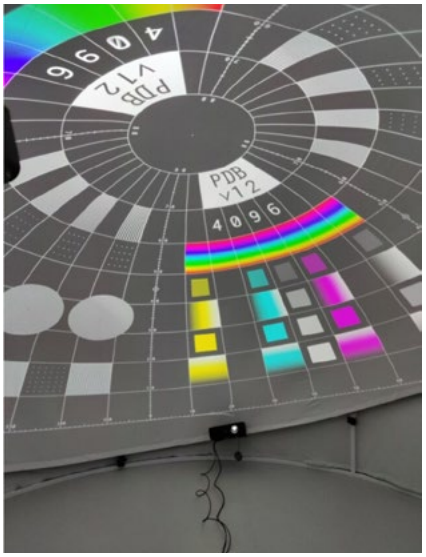
7. Attach the negative air pressure system.
8. Attach the dome projection fabric: Ensure it is free from wrinkles to provide a smooth surface.
9. Install the projection system: Set up the projection system within the dome structure. Ensure the secure placement of projectors. Plan for the placement of projectors to cover the entire dome surface with minimal distortion and shades.
10. Install the sound system: The dome includes a 5.1. sound system, one base speaker, and four smaller speakers.



Picture 41. Installing the AV equipment (photo: Martta Niemi).

11. Install the workstation and computer equipment.





Picture 42. Computer installation (photo: Martta Niemi).

Picture 43. Screen calibration (photo: Vaiva Stanisauskaite).

12. Prepare the camera and tripod for the calibration process.
13. Ensure the frame is stable and securely anchored to the ground to prevent any wobbling or instability. The dome we built was very small, only four metres in diameter, though we did not attach it to the floor.
14. Consider ventilation within the dome to prevent overheating, especially if using projectors for an extended period. It is important to always refer

to specific design plans and engineering considerations based on the size and intended use of your virtual reality dome. If you are not comfortable with the construction process, consider consulting with a supervisor.

Picture 44. The very first care dome is ready for use! (photo: Slavomir Kilian).

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