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MONA

Sustainable mobility within nature areas:

Literature review

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Summary

Nature areas in North-West Europe (NWE) face increased visitor pressure, leading to negative environmental impacts, higher management costs, and local nuisance. Traditionally they need to balance visitation and biodiversity protection, which is increasingly challenging due to this visitors growth trend. Recreational activities in protected areas cause ecological damage, such as soil erosion, vegetation degradation, and wildlife disturbance. Predominant car access exacerbates these issues . The Interreg NWE project MONA works on the encouragement of the modal shift to the nature areas, efficient routing and spreading strategies and nudging visitors towards sustainable behaviours. WP1 of MONA aims to support the development of evidence-based strategies and a monitoring framework for eight nature areas. It is supported by Deliverable 1.1.1. containing thematic literature review, expert interviews and selected case studies to inform sustainable mobility and visitor management strategies.

Research shows strong interrelations between tourism and transport. While overall there is a large body of research available on motivations for nature area visits, general mobility behaviour determinants and motives, there is a clear lack in systematic research and publications on determinants of leisure mobility behaviour, specifically to, from and within nature areas. Understanding visitor motivations and mobility choices is fundamental for developing efficient approaches to reduce car dependency. Tourism and leisure mobility have unique characteristics, including varying peak hours and seasonality impacts. To achieve a modal shift in car-dependent access to nature areas it is necessary to propose alternatives meeting leisure and tourists' needs. Studies highlight that car users value flexibility, especially for multi-destination trips. Rail tourism, connecting urban centres with rural areas, shows potential but faces barriers like high costs and infrequent services. Enhancing public transport and making railway stations and bus stops functional and attractive can facilitate the modal shift. Smart mobility innovations, like automated vehicles, IT platforms facilitating cooperation with different tourism stakeholders, as well as modern nudging techniques provide future opportunities.

There is a clear further research need in understanding of leisure behaviour. Effective nature park access strategies need to include a combination of push and pull measures to mitigate environmental impacts and improve visitor experiences. Routing should take a regional approach, cooperating with nearby attractions and diverting less-motivated visitors to less sensitive sites. Enhancing public transport quality is essential for encouraging modal shifts. Reliable and convenient transport options, particularly to and from railway stations, can significantly influence travel behaviour. For short-distance trips, improving transport quality to and from railway stations, integrating public transport timetables, and providing seamless connections will promote a shift from private car use to sustainable travel modes.

Introduction

Nature areas in North-West Europe (NWE) face an increasing number of visitors (intensified by COVID-19) resulting in an increased pressure on nature, negative environmental impacts, higher management costs, and nuisance for local residents and visitors. The high share of car use exaggerates these impacts, including peak pressures. Furthermore, the almost exclusive access by car excludes disadvantaged people, specifically those without access to a car. At the same time, the urbanised character of NWE, its dense public transport network, well-developed tourism & recreation sector, and presence of shared mobility providers offers ample opportunities for more sustainable tourism.

Interreg NWE project "MOdal shift, routing and nudging solutions in NAture areas for sustainable tourism" (MONA) aims to ensure that sustainable tourism practices in and around nature areas benefit nature, the environment, visitors, and the local economy. MONA does so by encouraging a modal shift through facilitating sustainable transport modes, providing inclusive routing to and within nature areas, and nudging visitors and stakeholders towards more sustainable behaviour.

D1.1.1 Literature review and current state of knowledge is part of WP1 "Develop evidence-based joint strategies and a monitoring framework". The objective of WP 1 is to develop evidence-based strategies on sustainable tourism through a modal shift, routing and nudging (for 8 nature areas) as well as a monitoring framework to measure the impact of the pilots on visitor flows and mobility choices. To reach this objective, 12 activities have been defined, from which this report concerns the results of the Activity 1.1 "Literature review and current state of knowledge".

The purpose of this activity is to provide a sound knowledge basis for the project and investigate some of the most relevant cases and experiences in the management of the nature areas in the NWE region, Europe, and other parts of the world. It focuses on the state-of-the-art regarding relevant concepts, such as (motivations for) visits to nature areas, impacts of tourism in and transport to nature areas, visitor flows to nature areas, and interventions aimed at influencing visitor flows and impacts. The objective is to provide an additional information for the general understanding of nudging, the role of (re-)routing in nature areas and modal shift to more sustainable travel modes.

The deliverable is composed of two Chapters:

- Chapter 1. Identifies the impacts of tourism and recreation mobility on nature areas and investigates both local and regional impacts and externalities.
- Chapter 2. Theoretical background and practical examples of sustainable mobility interventions provides an understanding of visitor motivations to nature areas, dives into the determinants of the visitors mobility behaviour to and within the nature areas and potential to influence those.

- Conclusions and recommendations, summarizing main take-aways from the experiences learned.

Literature review, interviews with MONA partners and interviews with external experts were performed to get a better understanding of the mobility impact on nature areas and potential pathways for the modal shift to/from and within nature areas. For this deliverable, a group of ten experts were interviewed, identified here by their role, addressing the gaps identified in the literature review: Associate Professor at the University of Primorska (Slovenia), CEO & Founder at tourism operator (UK), Researcher at the University of Applied Sciences and Arts Lucerne, (Switzerland), CEO & Founder of the digital (France), National Park Coordinator (Belgium), Nature Park Coordinator (Belgium), Director Regional Landscape (Belgium), Employee of Agency Nature & Forest (Belgium), Employee of Destination Management Organization (Belgium), Tourism Alderman of a municipality (Belgium).

Deliverable 1.1.1 serves as an input and inspiration for the development of the nature areas strategic plans. Knowledge received in this deliverable also served as an input to the drafting of visitor and resident surveys as well as the general market survey analysis.

Chapter 1. Impacts of tourism, recreation and mobility on nature areas

Nature-based recreation has grown over the years, further boosted by the COVID-19 pandemic. For example, in Germany between 2019 and 2021, the number of people who never undertake a hike in their spare time decreased by 10 per cent (Statista, 2023). Smith-Barneveld et al. (2021) also observed the increase in visitor numbers to nature areas in the Netherlands. In Norway, 82 percent of the population partook in hiking in and around mountains, forests and fields in 2021 (Trasavik et al, 2024). Overall in Europe, ETOA (2024) observes an increase (+19%) in demand for nature destinations for July and August 2024 compared to the year before.

While the United Nations recognizes access to nature as a human right, nowadays nature areas have to strike a precarious balance between nature conservation, and allowing for the provision of recreational and educational opportunities for visitors, in light of the increased interest to nature-based destinations. As mentioned by Leung et al. (2018) the types of impacts on the nature areas can be broad in their range and affect the natural fauna and flora, the local economies, local communities, and the tourists themselves. Impacts can be delineated regionally – within the nature areas, and within the wider surrounding region and macro-environment – and/or topically across environmental, economic, and social dimensions.

The existence or severity of different impacts depends on numerous factors, among which the typologies of nature areas and its regional context, but also the varied visitor motivations, behaviours, and mobility choices. Furthermore, management decisions on infrastructure development, zoning, and monitoring can play an important role in maximising positive and minimising negative impacts. While this Chapter therefore focuses on identifying a broad range of impacts – organized by local-regional effects and ecological, social and economic effects – it is important to further analyse these potential impacts in light of best-practice interventions discussed in Chapter 2, as well as the monitoring framework developed within the MONA project as Deliverable 1.4.

1.1. Nature area typologies

The literature refers to a variety of denominations in relation to nature areas: e.g. natural areas; nature reserve; wilderness area, national park, etc. The communality that brings all these denominators together is that "…natural processes predominate, fluctuations in numbers of organisms are allowed free play and human intervention is minimal (EIONET, n.d.). If these areas have a certain management status, they can be seen as protected areas.

Protected area is the concept that encompasses natural areas with various conservation, economic and/or social objectives (e.g., Watson et al., 2014). The International Union for Conservation of Nature (IUCN, 2008, 'Effective Protected Areas' section) defines a

protected area as: "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values." The latter status provides nature areas a more formal function and allows to generally benefit from more protection, although the lack of financial support can hinder these efforts (Watson et al., 2014).

IUCN (2008) distinguishes six management categories related to protected areas:

(1) Strict nature reserve and wilderness area;
(2) National park;
(3) Natural monument or feature;
(4) Habitat/species management area;
(5) Protected landscape or seascape, and
(6) Protected area with sustainable use of natural resources.

These management categories differ in the levels of human activity continuously interacting with the environment. The main objectives of these management categories are reflected in the level of human activity foreseen: the first, third, and fourth categories mainly serve the conservation of natural resources, while the second and fifth serve human purposes, while maintaining the integrity of the natural environment. The second and fifth category "fulfil a double mandate of both 'protection' and 'use'" (Butzmann & Job, 2017, p.1736). Furthermore, these categories can significantly differ in size, in which a natural monument or feature is generally small-scale and national parks are larger in size. Apart from the management categories, IUCN (2008) also distinguishes governance categories, which vary in the level at which authority and responsibility lies. The governance types include: governance by government, shared governance, private governance, and governance by indigenous peoples and local communities.

Table 1. MONA nature areas according to the IUCN management categories

MONA nature areas	Management category
Van Gogh National Park (NL)	National Park (II)
National Park Utrechtse Heuvelrug (NL)	National Park (II)
National Park Veluwezoom (NL)	National Park (II)
Grenspark Kalmthoutse Heide (BE)	Protected landscape or seascape (V)
Landschap De Liereman (BE)	Protected landscape of seascape (V)
Wortelkolonie (BE)	UNESCO World Heritage
Zuidrand (BE)	No specific protected status
Bliesgau Biosphere Reserve (DE)	Habitat/species management area (IV)
Hunsrück-Hochwald National Park (DE)	National Park (II)
Scarpe-Escaut Regional Nature Park (FR)	Protected landscape or seascape (V)
Montagne de Reims (FR)	Protected landscape or seascape (V)

The nature areas in the MONA project can all be seen as protected areas and vary in their management categories (Table 1). Since the areas are located in various countries with different management structures, 'nature areas' can be seen as an umbrella term which covers these variations.

1.2. Recreation and mobility impacts within nature areas

Recreation and tourism are important functions of nature areas, protected areas and national parks. So much so that the right to recreational opportunities is often enshrined in laws and mandates. For instance, the National Parks Act of Canada, written in 1930, states that National Parks are "dedicated to the people of Canada for their benefit, education and enjoyment … and shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations" (Government of Canada, n.d.). Similarly, National Parks in the United Kingdom are stated by law as having the dual purpose to (i) conserve and enhance the natural beauty, wildlife and cultural heritage, and (ii) promote opportunities for the understanding and enjoyment of the special qualities of national parks by the public (National Parks UK, n.d.).

This leads to inevitable challenges in balancing the needs for environmental protection with accommodating – often growing – numbers of visitors. While the designation of areas as protected zones or national parks has undoubted and well-documented positive effects on nature protection in a general and spatial sense – e.g., offering protection against damaging extractive industries – the potential pressures created by visitation have been equally well-documented, identifying both resource and social impacts. As mentioned by an interviewed national park coordinator:

> *"From the first visitor on, there is an effect on nature, which gets worse the more numbers rise. […] It then becomes an ethical-philosophical question: each visitor costs a piece of nature, but how much is this worth to us? If this visitation leads to a generation that will appreciate nature more, then it can become an advantage in 20, 30 years time." (National Park Coordinator)*

Recreation visitation to nature areas and national parks thus inevitably degrades natural resources and a challenge for management becomes to (i) limit the spatial extent of visitor impacts, and (ii) limit the severity of impacts where they occur. On an ecological level, visitation can lead to soil loss, vegetation degradation, degradation of water quality and wildlife disturbance. The most important social impacts are visitor conflicts and a compromised visitor experience. Furthermore, particular attention can be paid to mobility choices within the nature areas and their effects on the environment and wildlife.

Ecological impacts

It is important to recognize the positive effects brought forward by nature area designation – either offering a fully protected status, or minimally being zonally recognized as a space of nature conservation and recreation. While such designation is

not necessarily linked to recreation and tourism potential, often the value of such areas is at least partly inferred by a general public interest, which materializes itself into a recreational interest. Furthermore, visitors might provide an economic conservation rationale which, although not necessarily primary, can still offer secondary reasonings for inferring a – partial – protected status. Clearly, the main value of such recognition is the protection against alternative economic exploitation with potential lasting damages on the ecosystem. As such, considering opportunity costs and alternative development tracks, recreational nature areas help to protect local ecosystems, provide habitats for endemic and vulnerable species, and provide natural carbon sinks. Such beneficial effects are exemplified by Schedule 4 of the Crown Minerals Act 1991 of New Zealand which prevents mining access to, among others, national park land and nature reserves (Parliamentary Counsel Office, 2023).

Even though recreational nature areas therefore have net positive effects on the local ecology, it remains important to also recognize local, negative impacts of visitation in order to improve park management. As mentioned by a nature expert and coordinator of a nature park:

> *"When opening natural areas for recreational purposes, everything should start from the nature first principle and tourism is a tool to contribute to the support of nature, not the other way around." (Nature park coordinator)*

Summarizing over 80 years of recreation ecology research – the field of study focusing on potential undesirable visitor-related biophysical impacts to nature areas – Marion et al. (2016) identify four primary ecological topics of concern: vegetation, soil, water, and wildlife impacts.

A first, logical, impact of human recreation in nature areas is visitor trampling which can cause a decrease in vegetation cover, height, biomass, changes in species composition, and the introduction of non-native plant species. The effects on vegetation are mitigated/exacerbated depending on plant resistance – the ability to withstand direct effects – and plant resilience – the ability to recover from damage (Marion et al., 2016). Morphology has been found a dominant factor in this relationship with more rigid woody stems, shrubs, small trees, and tall herbs being both more susceptible to damage and less likely to recover, than grasses and graminoids which have preferential characteristics due to their flexible stems and leaves, fast growth rates, and bud at or below surface level (Hill & Pickering, 2009; Sun & Liddle, 1993). As a result of varying degrees of vulnerability to human trampling, cumulative, longer-term effects can lead to compositional changes in vegetation with forest herbaceous plants being replaced by graminoids, low-growing herbs, or mosses. The process might be further exacerbated by the introduction of non-native seeds which might outcompete native vegetation (Underwood et al., 2004; Pickering & Hill, 2007).

While herbaceous vegetation can be quickly lost at even low to moderate visitation, as long as visitors stay on well-established trails and campsites, a further increase in recreational visits does little additional damage to vegetation. However, potentially partly resulting from overvisitation and erosion of established paths, straying from designated tracks can create newly formed, visitor-created informal trails, also referred to as social trails. Leung et al. (2011) note how such informal trails can present a significant management challenge due to the lack of proper design and planning, and potentially leading to landscape and habitat fragmentation. Apart from ecological impacts due to soil compression, influencing meadow vegetation, such trails can also negatively impact hydrology and present barriers for small mammals and wildlife.

The impact of recreation-based trampling on the underlying soil depends on soil structure, use level, and type of use. First of all, impacts differ by soil component. The upper soil layer, consisting of organic litter – i.e., the layer of partially decomposed plant material, such as fallen leaves, twigs, and dead plant matter – is already affected by initial and low levels of trampling, initially flattening and speeding the degradation of organic litter. Increase levels of trampling cause pulverization of the leaves and twigs, accelerating their loss to wind and water or decomposition into the underlying organic soil. This process can most directly affect the various small organisms for which organic litter provides a habitat, as well as influencing the nutrient cycling. The organic soil is the secondary layer, also known as histosols, containing a high proportion of organic matter, characterized by a dark colour and high organic carbon content. When exposed to traffic – and particularly in sloping terrains – organic soil can be rapidly displaced and lost as a result of its low density and lack of structure. Underneath, the mineral soil layer is the layer that primarily consists of mineral particles such as sand, silt and clay, with a lower organic content. Recreational pressure compacts mineral soil, with the effect strongly linked to the mechanical force exhibited – e.g. Thurston and Reader (2001) and Liddle (1997) provide estimates of 0.29 kg per cm^2 for hikers, 0.35 kg per cm^2 for mountain bikers, to 4.38 kg per cm^2 for a horse and rider. These forces cause soil density to increase, leading to smooth, hardened surfaces that can prevent germination, plant root penetration, and water permeability. While such compaction can help to deter displacement of soil, poor drainage can cause formation of puddles and trail muddiness, which might lead visitors off the established trails (Marion et al., 2016). However, the effects of different types of use are also invariably linked to the available infrastructure. For instance, while in general a cyclist can be thought to have more significant mechanical impacts, this is less the case for purely recreational cyclists that remain on predefined, hardened cycling paths. As mentioned by an interviewee:

> *"The ecological impact of a hiker is, for instance, larger than a cyclist. A hiker with a dog has still a higher impact than a cyclist. A hiker with an unleashed dog is very negative." (Director Regional Landscape)*

A longer-term soil-related problem is the potential for erosion – especially water-based erosion – particularly in sloping terrains with elevation rates exceeding 10%. Soils with silt and fine salt are most susceptible to these effects due to their finer particles. Soil loss might lead to the exposure of roots and rocks, causing hikers to look for alternative paths, and affect water resources (e.g., increase in turbidity and sedimentation). Furthermore, on a human-time scale, soil loss is considered nearly permanent due to the very slow geological recovery process (Marion et al., 2016).

Visitor impacts on water resources can be characterized as physical, biological, and chemical. Physical impacts predominantly relate to flow alteration, shoreline erosion, and effects on water clarity. Biological effects typically involve the introduction of non-native flora and fauna and the increase in coliform bacteria and protozoa. Chemical impacts are related to nutrient impacts on oxygen levels and pollution from soap, sunscreen, food particles, and waste (Marion et al., 2016). The type and level of these effects depends on the type of visitor activities in nature areas. Direct impacts resulting from water-based activities such as swimming, boating, and kayaking have a higher change of inducing chemical impacts while also stirring settled sediments on the river/lakebed which can in turn increase turbidity and reduce levels of dissolved oxygen which affects plant photosynthesis of aquatic vegetation (Marion & Sober 1987). Indirect effects from walking along streams and shorelines is linked to the earlier discussed vegetation trampling and soil compaction, potentially increasing erosion and nutrient influxes (Clow et al., 2011, 2013).

The impact of recreational visitation on wildlife is challenging to study due to the complex nature of the interaction, the important mediating effects of visitor behaviour and animal type – e.g., particularly the timing of breeding, nesting, and rearing of young – spatial and temporal lag effects, and the ability for animals to exhibit learned behaviour (Taylor & Knight, 2003). Therefore, as mentioned by an interviewee:

> *"Since not every disturbance is easily measurable, such as for instance disturbance of birds, we most often employ preventive measures to forbid certain recreational activities during breeding season. This is different from other habitat damage which is more easily measurable and linked to visitation." (Agency Nature & Forest)*

Direct impacts have been classified as exploitation and disturbance, with exploitation relating to animal deaths (e.g., due to vehicle collisions) and disturbance referring to temporal or permanent spatial displacement of wildlife as a result of habitat disturbance. Indirect effects can relate to habitat alteration or pollution, both indicating habitat effects which might in turn change animal behaviour, spatial distribution, and reproductive ability (Hammitt et al., 2015; Marion et al., 2016).

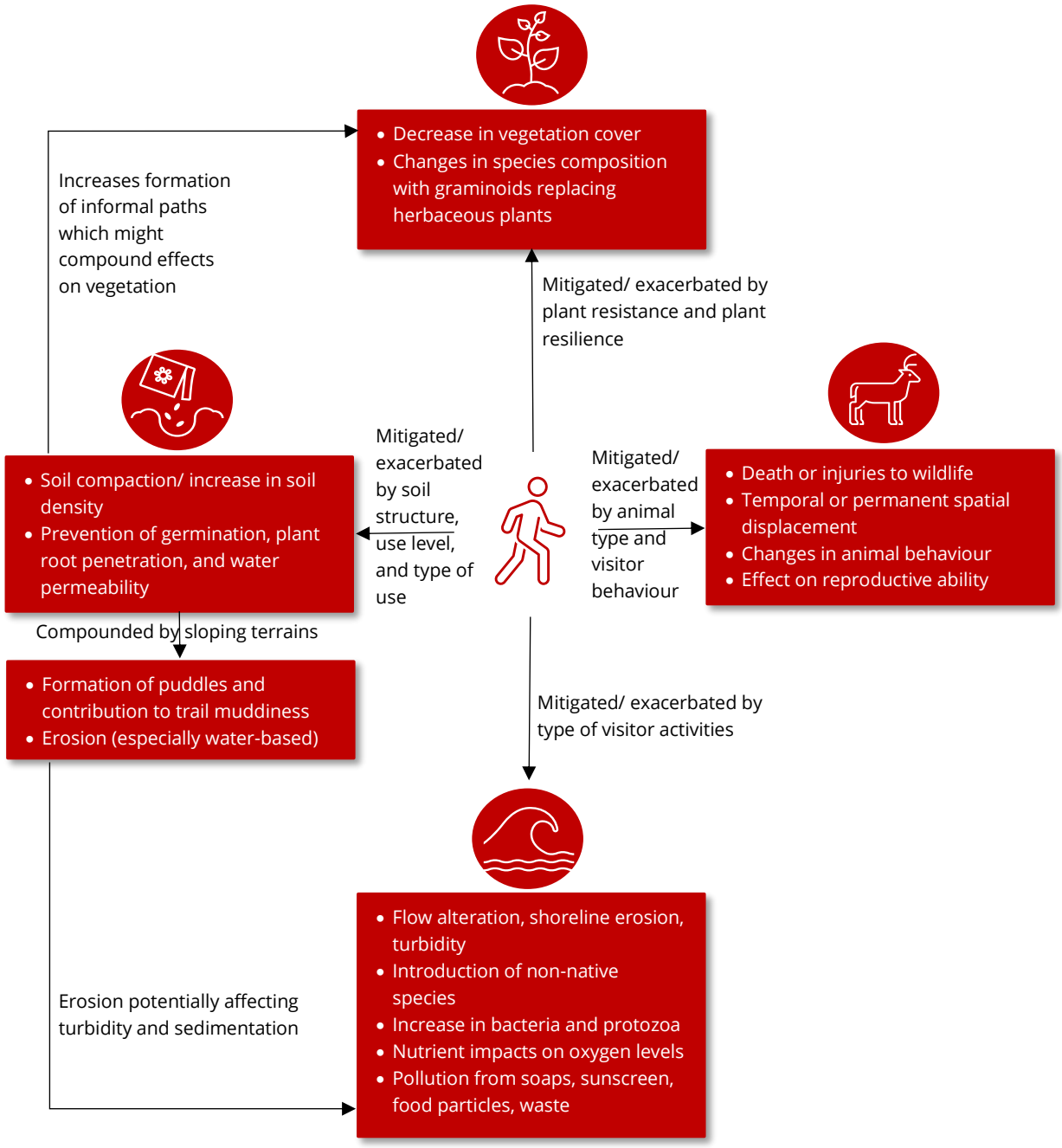

Figure 1. Visitation effects on ecological park resources (Source: own work)

Social impacts

Positive effects of nature recreation have been linked to better physical and mental health, as well as potentially providing educational benefits to visitors. Physiological benefits are linked to the potential for activities such as hiking, cycling, and running, with long-term health benefits of exercise linked to a reduction in the risk of heart attacks, increased cardiovascular fitness, and a lowered cholesterol (Maller et al., 2009), although such benefits are obviously strongly related to frequency of such activities and therefore more likely to occur for people living in closer proximity to parks, particularly in urban

landscapes (Alvarez & Larkin, 2010; Godbey et al., 2005). Stodolska et al. (2011) further identified correlations between physical and psychological benefits of park visits. Research on mental health benefits dates back to at least the late 1970s with More and Payne (1978) finding that park users reported lower anxiety and higher happiness after visitation, which was later corroborated by Godbey and Blazey (1983). Hull and Michael (1995) later added a longitudinal component to these findings, reporting how longer visits further decreased stress levels. The next decades of empirical research broadly validated these early findings and it is now commonly agreed upon that visits to nature areas can lead to broad and holistic health and wellness benefits, thereby also potentially reducing societal mental health costs in general (Buckley, 2020; Heintzman, 2013).

Similar to ecological impacts, even though the net balance in terms of social impacts is undoubtedly positive, increased visitation has also highlighted potential negative social impacts at the local level, particularly in the visitor-to-visitor relationship. The possible negative social impacts of visitors on the quality of the recreational experience have long been established in outdoor recreation research, dating back to the 1960s when it was recognized that an application of carrying capacity to recreational lands required both environmental and social components. This early scientific attention can be contributed to the underlying motivation for visiting nature, which is often linked with a desire for solitude and wilderness experiences.

Much of the literature on social impacts focuses on the concept of crowding, whereby crowding is defined as a negative psychological state caused by an overexposure to visitor contacts and a dissatisfaction with prevailing use numbers. As mentioned in one of the interviews:

> *"You can also get a feeling of crowdedness. A feeling that the park is too full. […] You go to a nature park to preferably not see other people, you don't want to see other hikers three metres in front of you." [Destination Management Organization]*

In effect, crowding takes place at the point where visitors experience unsatisfactory recreational visits. While simple in concept, operationalizing crowding has proven rather complex for a number of reasons. First of all, crowding relates to a normative assessment of use numbers and encounters, thereby not being solely influenced by the amount of visitors, but also by situational, contextual, personal, and interpersonal characteristics. Secondly, even when negative crowding levels are experienced, its effects on visitor satisfaction are often small, which can be attributed to human adaptability potential – either by limiting cognitive dissonance or by changing spatial/temporal travel patterns.

In terms of identifying causal and mediating factors of crowding perception, Manning (1999) provides a concise overview of the existing literature, identifying three broad categories that can influence normative crowding standards: (i) Personal characteristics of visitors, (ii) Characteristics of other visitors encountered, and (iii) Situational variables. Under personal characteristics, visitor motivations have consistently been found to

influence normative assessments of crowdedness (Mieno et al., 2016). For instance, Ditton et al. (1983) found that visitors reporting higher motivation ratings on "getting away from other people" were significantly more likely to experience crowding, than visitors who reported that part of their enjoyment was enhanced by contact with others, being motivated by "being part of a group", "to have thrills and excitement", or "to share what I have learned with others". Similarly, individual preferences for contacts and visitor expectations play an important role in crowding perception (Schamel & Job, 2013), the latter indicating the importance of providing prospective visitors with up-to-date information on the current state of visitation. A final personal characteristic that is often considered and consistently found to influence perceived crowding is the visitor experience, although it has been found to both alleviate and exacerbate affective responses to visitor numbers. While repeat visitation can improve expectations or allow for a better understanding of place – and therefore, trail alternatives – the bulk of empirical evidence nevertheless seems to indicate a positive correlation between experience and crowding perception (i.e., higher experience levels increasing the sensitivity to higher use levels) (Arnberger & Brandenburg, 2007). A reason for this relationship could be that experience in nature visitation and hiking is often linked with stronger preferences for low-density hiking, solitude, and wilderness experience (Steward & Carpenter, 1989).

As a second grouping of variables, it is reasonable to expect that the tolerance for use numbers at least partially depends on the characteristics of these other groups of visitors. Firstly, conflicting use types – e.g., hiking, mountain biking, horse riding – can cause dislike and heighten crowding perception. Not completely dissimilar to use types is the effect of tourist behaviour, which has at times been found to be more influential than actual use numbers, with particularly noise, yelling, loud behaviour, littering, and non-compliance with rules affecting crowding norms (Neuts & Nijkamp, 2012). Finally, party size of other groups encountered can influence crowding perception with visitors often declaring a preference for meeting multiple small parties, rather than one large group during a wilderness experience (Manning, 1999).

Finally, under situational variables we can identify inter-area and intra-area effects on crowding norms. Inter-area differences are noticeable when distinguishing crowding norms for different types of parks and other nature-based and non-nature based tourism destinations, with wilderness areas invoking stronger crowding reactions than similar use levels in, for instance, seashore beaches, or urban and peri-urban parks (Arnberger, 2006). However, also within nature areas itself there are important local differences in crowding norms, whether related to campsites, starting points of trailheads, or different types of interior zones (Schamel & Job, 2013). Somewhat related to this is the effect of perceived environmental quality, whereby more negatively perceived ecological park conditions can elevate perceived crowding and preferred visitor contacts.

Motorized mobility impacts

Local within-park motorized mobility is first of all dependent on size, regulations, and road availability. In many cases though it is common for large nature areas to be partly dissected by roads, thus also inviting motorized traffic within its boundaries. Understandably, this can cause important impacts such as noise pollution, wildlife disturbance and injury, changes in the environmental chemical composition, and general atmospheric emissions (Monz et al., 2016; Trombulak & Frissell, 2000).

Noise pollution can have both experiential and ecological consequences. From an experiential perspective, while nature sounds can facilitate stress recovery, transportation noise potentially decreases positive feelings. For wildlife species, anthropogenic noise can affect panoramic environmental awareness which is important for a wide array of animal behaviour, ranging from sexual communication to territorial defence, habitat assessment, and predator/prey hunting interactions. As such, transport noise might interfere with natural sounds and impede on activities essential for survival (Francis & Barber, 2013; Monz et al., 2016).

Animal mortality due to road collisions can at times have substantial effects on a population's demographic composition and is particularly significant for amphibians due to their migratory nature and slow movement (Trombulak & Frissell, 2000). The modifying behavioural effects have also been extensively studies with, for instance, increased avoidance being found for both grizzly bears and Dall's sheep in Denali National Park and Preserve (Phillips et al., 2010) and Northwestern Montana (Waller & Servheen, 2010).

Trombulak and Frissell (2000) mention at least five general classes of chemicals that road use and road maintenance contribute to the local environment: heavy metals, salt, organic molecules, ozone, and nutrients. Heavy metals contaminations can include lead, aluminium, iron, cadmium, copper, manganese, titanium, nickel, zinc, and boron and are directly related to the amount of traffic and proximity to the roadside, with elevated levels of heavy metals often occurring up to 200 metres from the road. These heavy metals can be localized both close to the surface and deeper within the soil and also accumulate in plant tissues and animals.

In terms of general atmospheric emissions from local mobility, Wilkins et al. (2024) note in their study on Yellowstone National Park that, even though transits within the park only account for approximately 5% of total emissions – with a majority of emissions being related to transfers to and from the destination – this still amounted to approximately 51 million kg of CO_2, 37 million of which was related to private car use. The authors further mapped out a hypothetical scenario of implementing public transits during the summer, potentially resulting in 25% of visitors changing from private car use to public buses, which could decrease the within-park transit emissions by around 7%. Furthermore, in a stated choice experiment conducted by González et al. (2019) in the Teide National Park, the authors found a positive willingness to pay of visitors for a park shuttle bus connecting the

main point of interest, which could then lead to reduced time of finding parking space and reduced CO_2 emissions by relieving dependence on personal vehicles.

1.3. Local and general recreation and mobility impacts

Recognizing the potential consequences for neighbouring communities around established national parks and nature areas, Fortin and Gagnon (1999) conducted a four-year social impact assessment of park-community relations around two Canadian national parks. Relevant identified impacts in the local communities were: (i) Impacts on local resource management, (ii) Impacts on the local economy, and (iii) Impacts on living conditions – including road congestion, (iv) Impacts on the involvement and participation of local actors. Furthermore, on a more macro-environmental level, transportation to and from nature areas – and associated mobility choices – generate general atmospheric emissions.

Impacts on local resource management

The establishment of conservation areas has a direct impact on local resource management, whereby a portion of local lands is being zoned exclusively for conservation, excluding other development options. This can further lead to modifying recreational use and economic activities, and removing local control over the territory. The resulting effects on recreational opportunities for local communities can be inconclusive and partially depend on recreational preferences. On the one hand, protected nature areas can offer increased potential for soft recreation such as walking, hiking, or mountain biking, on the other hand, motorized recreation and extractive activities such as hunting and fishing might be largely prohibited (Jones et al., 2016). Furthermore, in national park areas functioning according to the American model of park management, whereby human populations are not tolerated, the consequences could be even more dramatic, resulting in relocation of communities and the uprooting of indigenous populations and livelihoods (Fortin & Gagnon, 1999; West & Brechin, 1991).

Impacts on local economy

Impacts on the local economy have been among the most studies subjects of positive nature areas externalities. Firstly, Fortin and Gagnon (1999) mention the creation and/or improvement of park infrastructures such as roads, trails, interpretative centres, but also the more general injection of government funds into the regional economy as positive economic effects. Other economic benefits directly linked to its recreational use depend on the level of supra-regional attraction potential and integration of the nature area with adjacent tourist services, with potential to stimulate new tourism enterprises and a diversification of the economic basis, while also encouraging the local manufacture and sale of goods and provision of services (Leung et al., 2018). One interviewee mentioned the importance of the "Cycling through the Trees" tourism experience for local entrepreneurs:

> *"'Cycling through the Trees', certainly is a project where the hotels, restaurants and bars saw the 'before' and 'after' effects. Overall this has been a very positive experience with more visitors, and more income. The supply was effectively too small for the demand, because all places were fully occupied. At the same time, this also led to restaurants and bars closing additional days because it became too busy and they couldn't find enough personnel to accommodate those busy days." (Tourism alderman)*

According to statistics from the National Park Services, in 2021 approximately 297 million visitors spent US$20.5 billion in communities within a 60 mile radius of US national parks, supporting 322,600 jobs, 268,900 were in park gateway communities with particularly significant effects in accommodation and restaurant sectors (National Park Service, 2022). Bennett et al. (2013) Focused their research specifically on the economic value of Dorrigo and Gibraltar Range National Park in Australia, identifying a direct per capita economic value of recreation use of AU$34 and AU$20 respectively, or AU$5.4 million for Dorrigo National Park and AU$0.8 million for Gibraltar Range National Park on an annual basis. The accompanying indirect regional impacts were estimated at over AU$4 million in output, and AU$2.3 million in value added – including AU$1.5 million in household payments to 71 people – for Dorrigo National Park, and AU$1.5 million in output, and $0.9 million in value added – including AU$0.6 million in household income for 30 people – for Gibraltar Range National Park. Within Europe, Mayer et al. (2010) studied the economic impact of six German national parks (Niedersächsisches Wattenmeer, Bayerischer Wald, Eifel, Müritz, Hainich and Kellerwald-Edersee) and concluded that, while considerable, average daily expenditure of national park visitors was considerably below average – between €7 and €13 for day visitors and €37 and €57 for overnight visitors – compared to general tourism expenditure. The total economic impact of recreation significantly varied between the parks, ranging from €525 million in Niedersächsisches Wattenmeer and €1.9 million in Kellerwald-Edersee, identifying the potential of qualitative upgrading of adjacent tourism services, improved marketing and the promotion of a diverse and regional supply chain.

Impacts on living conditions

In terms of living conditions, Fortin and Gagnon (1999) mention a change in orientation towards tourism and hospitality-related jobs where, in a number of cases, the rapid increase in tourism development coincided with a cost of living increase, particularly in terms of accommodation costs and market value of private properties.

Potentially more significant and ubiquitous, increased popularity of the destination for regional and international visitors can also strain local resources and create particular bottlenecks on roads and parking spaces. As discussed by Jaarsma et al. (2009), the increased popularity in rural and nature-based tourism can cause traffic congestion and parking problems in areas where the infrastructure is often incapable of dealing with a growing number of cars. Such issues are exacerbated by the fact that individual car use is

by far the predominant mode of transportation to and in rural destinations. McGinlay et al. (2020) highlight how, during the COVID-19 pandemic, such challenges were exacerbated further with parking in non-designated areas and increased traffic due to the avoidance of public transport and organized groups.

An imbalance between available parking spaces and demand leads to increased pressure on local communities when visitors use non-designated parking areas in village centres, residential streets, and next to the side of roads. This was also noted in one of the interviews:

> *"The additional crowds being attracted by the 'Cycling through the Trees', product has created somewhat of a negative atmosphere among the local residents. This is subsiding again, but there was much nuisance caused by tourists who didn't keep to the regulated parking spaces and parked irregularly on people's driveways." (Tourism alderman)*

This can lead to a vicious cycle whereby an increase in parking problems in residential streets requires management solutions in the form of additional new parking facilities – as has for instance been the case for the new parking spaces at Ter Dennen at the Nationaal Park Hoge Kempen in Belgium, meant to resolve parking issues at the Daalbroekstraat – which by themselves create additional space demands and pressure on local nature resources and conversely potentially invite more car mobility and general visitation (Weitowitz et al., 2019). Furthermore, high car-based mobility on a limited number of entrance roads, combined with informal parking next to the roadside can lead to traffic congestion and unsafe road situations. For instance, during the Covid-19 pandemic, the three main entrance roads N68, N67 and N676 towards the Belgian Hautes-Fagnes nature area had to be closed completely for private cars during certain snow-filled weekends due to congestion effects – including roadside parking extending 14 km – creating unsafe conditions.

Impacts on local involvement and participation

The establishment of national parks and protected nature areas can further prompt a mobilization of local actors, through active participation in public hearings, dialogue groups, and partnerships between a park and local non-profit organizations (Fortin & Gagnon, 1999). In such cases, parks can both be catalysts for community engagement and depend on such engagement for ensuring the integrity of protected areas, as suggested by Andrade and Rhodes (2012). Cerveny et al. (2022) use the example of National Scenic Trails to emphasize the partnership models with community-based stewardship organizations in trail planning, development, maintenance and management, while also supporting community resilience through such established networks.

General environmental effects

As discussed before, in many nature areas and national park settings a majority of visitors depend on private car use, not only influencing local living conditions – in terms of traffic

congestion and parking issues – but also contributing to global emissions. In a study on five national parks in Taiwan, Lin (2010) compared CO_2 emissions per passenger kilometer for four modes of transport, identifying highest emissions from private cars (0.097 kg/pkm), as compared to vans (0.075 kg/pkm), motorcycles (0.054 kg/pkm), and tour busses (0.028 kg/pkm). Relative emissions were strongly affected by load factors which were logically much lower for private cars (2.2) than for tour buses (33). In terms of total transport-related emissions in 2006, the national parks ranged from a high of 59.8 million kg of CO_2 for Kenting National Park, to 7 million kg of CO_2 for Sheipa National Park, with significant influences of visitor numbers and average distance travelled. The potential of modal shift was made obvious by a scenario analysis in which the author estimated that CO_2 emissions could be reduced between 22% for Kenting National Park and 26% for Sheipa National Park, in a scenario whereby 40% of tourists would switch from private cars to tour buses.

A similar study for Yellowstone National Park by Wilkins et al. (2024) revealed that almost 90% of all park-related emissions could be contributed to transit to and from the destinations, with only 5% being related to transit within the park, 4% from overnight accommodations, and about 1% from other park operations. While the inclusion of international (on average 1,199.11 kg of CO_2 per visitor) and domestic flights (on average 405.6 kg of CO_2 per visitor) meant that they took the largest share of emissions, cars were found to contribute 67.11 kg of CO_2 per visitor for local visitors, and an average of 219.83 kg of CO_2 per tourist for non-regional visits. Since a majority of visits (64.4%) were done exclusively by car, total yearly emissions for this mode of transportation were estimated at 253 million kg of CO_2.

Chapter 2. Theoretical backgrounds an practical examples of sustainable mobility interventions

Considering the growth of nature-based tourism, its high dependence on car transport and negative impacts that it generates on the nature areas and around them, there is an evident need in a modal shift to more sustainable transport modes and adaptive visitor behaviour. Feng (2023) notes that "both tourism economy and tourism traffic are complex systems formed by a variety of elements through interaction between each other, the two systems affect each other and restrict each other". Hussain et al (2023) also identify the strong mutual relationship between smart mobility and smart tourism, specifically in rural areas. Thus, in order to better understand potential efficiency of any approaches or measures developed for modal shift, it is first necessary to get an insights of some theoretical foundations in relation to the recreational mobility behaviour and barriers and opportunities of sustainable modal shift. Nudging, being often deployed as a tool guiding consumers to certain decisions is being widely used in sustainable tourism and has a large potential in guiding sustainable mobility behaviour.

Chapter 2 deep dives into the specific examples of sustainable mobility and management interventions, first addressing their theoretical foundations. Based on MONA nature areas priorities, case studies were organised under three topics: routing and spreading; modal shift and nudging. Each sub-section introduces relevant theoretical concepts, provides examples of interventions based on the literature review and expert interviews and deep dives into concrete cases.

2.1. The need of routing and spreading: motivations for the nature area visits

Within MONA project, Pilot 2 group, bringing together Tourism Province of Antwerp, in Belgium, and Visit Brabant and National Park Veluwezoom, from the Netherlands, are specifically focusing their activities on routing and re-routing for the purpose of sustainable mobility behaviour, improved visitor spread within and outside of nature areas, and more efficient use of strained natural resources. The MONA project analyses the use of entrance gates, visitor flows and visitor (mobility) behaviour in the partner areas and thereby aims to investigate opportunities to better manage visitor flows. Within the subject of routing and spreading, an important consideration to make is the relevant tourist motivations and behaviours within nature areas, since they can affect re-routing opportunities and limitations. For instance, De Valck et al. (2016) conduct a hot and cold spot analysis for preferred outdoor recreation activities for people of the Antwerp province in Belgium and note significant differences between hikers, cyclists, dog walkers, and runners, both in terms of preferred location and in terms of substitutability.

Tourist motivations to visit nature areas

Tourist or travel motivations have been a point of attention since the late '70s and continuing through the early 2000s (e.g., Dann 1977; Crompton, 1979; Iso-Ahola, 1982;

Pearce, 2005), as well as visitor values, motivations, and activities specifically in the context of natural or protected areas. Ram (2020) establishes numerous advantages of nature for tourism: e.g. recreation, education, socialisation.

Arnegger et al (2010), propose a nature-based tourism typology, illustrating its demand and supply side (Figure 22). The demand side (horizontal) is sorted based on the extent to which nature is seen as the attraction. The four visitor motivations are related to the activities visitors undertake:

- 'nature protection',
- 'nature experience',
- 'sports and adventure', and
- 'hedonistic'.

High "nature as point of attraction"** Low

"individuality"* (High) / Service arrangements \ Travel motivations	Nature protection	Nature experience	Sports and adventure	Hedonistic
Independent	Scientific/professional expedition	Birdwatching	Classic alpinism	Backpacker visiting protected areas and nearby cultural attractions
Á la carte	Excursions provided by authorities for visiting professional s	Snorkeling tour booked on-site	Whitewater rafting booked on-site	Combined culture/nature daytrip booked at a local agency
Customized	Volunteer work in protected areas for NGOs	Birding holiday with professional guide	Guided fly-fishing trips for small-sized groups	Cultural/natural circuit tour often in small groups and over several weeks
Fully standardized (Low)	"Packaged" volunteer work in protected areas, often provided by commercial intermediaries	Standardized daytrips to protected areas included in or booked as an add-on to all-inclusive 3s holidays	Scuba diving holiday package	Standardized circuit tour organized in larger groups

*Figure 2. Nature-based tourism typology (*Source: Arnegger et al, 2010)

The supply side (vertical) is based on the level of standardization of the tourism products offered. The four vertical levels range from independent trips to fully standardized packages. Travel preferences have also been modelled in the Recreation Experience Preference Scales (REP scales) (Manfredo et al., 1996), which distinguishes five main preferences, comparable to Arnegger's (2010) four visitor motivations: recovery, nature, sports, fun/relax, and adventure.

However, within the REP scales overlapping preferences can be observed (e.g., fun, adventure, and sports) whereas the items from Arnegger et al.'s (2010) typology are similar but does not contain these ambiguities. This highlights Arnegger et al.'s (2010)

dilemma between theoretical typologies that stress diversity and pluralism, but lack practical relevance, versus managerial typologies that might not translate well to other contexts. As Arnegger et al.'s (2010) typology has been empirically tested by Butzmann and Job (2017) and has been used in the context of nature-based tourism, this typology might prove to be useful in the context of North-West European Nature Areas.

Cheung and Fok (2013) found similar travel motivations in the context of nature-based tourism, namely travel for novelty, for recreation, and to escape, which show similarities with Arnegger et al.'s (2010) nature experience, sports and adventure, and hedonistic, respectively. However, Cheung and Fok (2013) also linked these travel motivations with underlying pro-environmental value systems. The three value systems the authors found differ in the prioritization of nature versus leisure, and are defined as: 'conservation priority', 'conservation and development', and 'leisure rights'.

The authors found correlations between some value systems and travel motivations. Travelling for novelty or recreation (similar to nature experience and sports and adventure, respectively) are associated with higher levels of environmental concerns, whereas travelling to escape is associated with lower levels.

Carvache-Franco et al. (2019) found three segments in the context of coastal ecotourism which show similarities with the former segmentation models. The authors included motivational factors from various tourism niches, such as self-development, interpersonal relationships, building relationships, escape, nature appreciation and reward (Carvache-Franco et al., 2019). The segments that they distinguish are 'nature', 'reward and escape', and 'multiple motives'. Similar to Arnegger et al.'s (2010) typology, the segments differ in the extent to which nature is the main motivation for visitation. However, it differs from the aforementioned typology in that the segments 'reward and escape' and 'multiple motives' view nature as a motivation next to some other, or all other motivation categories, respectively. Unsurprisingly the 'nature' segment's main motivation is nature appreciation, while the other motivators do not play a major role.

Ramkisoon et al. (2013) make the connection between several concepts related to visitor motivations and pro-environmental behaviour. For example, the authors argue that place dependence, "the awareness of the uniqueness of a place and its ability to provide desired leisure experiences" (Williams et al., 1992, as cited in Ramkisoon et al., 2013, p. 436), leads to pro-environmental behaviour intentions, as they depend on this very environment to meet their needs. Similarly, place attachment, which relates to the emotional bonds that visitors can form with a place (Ramkisoon et al., 2013), has also been found to positively relate to pro-environmental behaviour. Especially with repeat visits the visitors' attachment to place could serve as their motivation to visit.

An often-mentioned theory in tourist motivations is the push/pull-model (Dann, 1977), which takes into account both demand and supply dimensions and due to its general nature, is applicable to a multitude of contexts. This model shows similarities with various

segmentation and motivation models described below, in that motivations for nature area visitations can range from 'pull-factor dominant', in which nature is the attraction, to 'push-factor dominant', in which nature is the backdrop in which intrinsic motivations or needs are met.

Overtourism and nature area management

As mentioned in Chapter 1 and building on the variety of motivations to visit nature areas, last years have seen a constant growth in the number of visitors to nature areas. This development has a clear impact on nature and biodiversity and raises the necessity to balance visitor access and visitor flows to and within nature areas, ensuring sustainable tourism practices and nature preservation and mitigating the potential of overtourism. As Anya Niewarra, director of Visit Zuid-Limburg says: "If you look at the transition in rural areas, the main challenge in South Limburg is to rebalance recreational mobility…" (Destinatie Nederland, 2024).

In its broadest and simplest form, the term 'overtourism' refers to excessive numbers of tourists resulting in negative impacts at a destination (Dodds & Butler, 2019). Peeters et al. (2018) extent this definition by discussing the importance of type and timeframe of tourist visits and the carrying capacity of a destination, defining the concept as: "…the situation in which the impact of tourism, at certain times and in certain locations, exceeds physical, ecological, social, economic, psychological, and/or political capacity thresholds" (Peeters et al., 2018, p.22). While the concept of overtourism gained traction since 2016, when it was coined in a Skift-report, and has seen a broad uptake in academia and popular press, it is often framed within urban contexts, juxtaposing local residents and cultures with visitors. In concept, though, 'overtourism' is largely a vestige of earlier theories on carrying capacity and crowding, which have their grounding in both ecology and environmental psychology and have long been part of the research scope of outdoor recreation and nature area management. In effect, the first notions of carrying capacity as a relevant concept for park management dates back to the mid-1930s, although a more rigorous application has only occurred since the 1960s. The addition of the human perspective through crowding studies has had its foundations in the 1970s (Manning, 2002). From these perspectives we have learned that visitor carrying capacities are a complex combination of actual ecological boundaries, visitor experiences and expectations, behaviour, and effective use numbers/encounters. For instance, Luque-Gil et al. (2018) identified how visitors with diverse visitor profiles, ranging from nature visitors, social visitors, sport visitors to learning visitors, have different needs and expectations and different degrees of crowding perception in the Sierra de las Nieves mountains, thus explicitly linking motivations, with required facilities, and perceived social carrying capacity. On the other hand, as was discussed in Chapter 1, different visitor profiles also influence environmental degradation to a different degree, with, for instance, mountain biking having – on average – a larger impact than hiking and going off-track

being more detrimental to ecological values and natural habitats than following pre-defined routes.

The main take-away of the literature is the multi-dimension nature of carrying capacity, which for nature areas primarily relates to an ecological and a social maximum and optimum. While ecological carrying capacity is biologically and geologically defined, social carrying capacity relates mostly to visitor experiences which were already introduced in Chapter 1 with the crowding-concept being identified as one of the main potential social impacts of nature recreation. When considering unsustainable or sub-optimal visitation and recreation, it is thereby important to identify the source of the disturbance before considering potential solutions. Similarly, in nature area management it is critical to consider ecological and recreational aspects simultaneously. This approach is clearly present in the Visitor Experience and Resource Protection (VERP) framework, developed by the US National Park Service in which nine essential elements are recognized: (i) Assembling an interdisciplinary project team; (ii) Developing a public involvement strategy; (iii) Developing statements of park purpose, significance, and primary interpretive themes; identifying planning constraints; (iv) Analysing park resources and existing visitor use; (v) Describing a potential range of visitor experiences and resource conditions (potential prescriptive zones); (vi) Allocating the zones to specific locations within the park (prescriptive management zoning); (vii) Selecting indicators and specifying standards for each zone; developing a monitoring plan; (viii) Monitoring resource and social indicators; (ix) Taking management actions (Hof & Lime, 1997).

Within nature area planning and management, routing of visitors is therefore an essential factor, linked with the identification of conservation levels and different park zones, as stated in steps 4 to 6 of the VERP planning approach. A practical application in this regard can be found in the Recreation Opportunity Spectrum (ROS). ROS was developed from the perspective that the output of recreational resources is more than just providing recreational activities and that desired experiences are inextricably linked with preferred activities and physical (e.g., landscape characteristics, type of access, remoteness, size), social (e.g., user density, proximity versus privacy, behaviour), and managerial (e.g., regulations, information, interpretation, facilities and site management) settings (Zeng et al., 2021). Janowsky and Becker (2003), using the example of the urban forest of Stuttgart, for instance provide a relevant overview of the type of forest trail facilities that are preferential for different users groups such as hikers, joggers, horse-riders, mountain bikers, etc., identifying differences in width, surface, trail condition, grade, and route structure.

This approach therefore supplements the vision of the Europarc organization that identify a one-dimensional view on carrying capacity as a main problem of nature area management and call for a better integration of the resource dimension, the experiential dimension, and the managerial dimension (Parks & Benefits, 2012). ROS traditionally identifies six main classes: (i) Primitive, (ii) Semi-primitive non-motorized, (iii) Semi-

primitive motorized, (iv) Roaded natural, (v) Rural, (vi) Urban. Within these six classes, characteristics such as level of access, management, facilities, and social encounters go from minimal (in primitive settings) to high (in urban settings), while the level of remoteness goes from high (in primitive settings) to minimal (in urban settings). The ROS provides a relatively simple and intuitive approach to zoning, starting from an identification of most valuable and critical ecosystems and habitats – the pristine or primitive areas where visitor facilities such as trails, signage, benches should be non-existent or areas should be closed off altogether – to identifying nature areas with more robust ecological carrying capacities located closer to entrance gates and urban habitats and where experiences might be offered for different recreational motivations (e.g., hiking, mountain biking, play-forests for children). In such areas, facilities should be provided to support the planned activities, whereby trail facilities and signage by themselves already lead to routing people along pathways.

A combination of hardware (e.g., marked trails, signs, watchtowers) and software (e.g., information, education) linked with zoning of activities that take into account vulnerable nature areas are therefore valuable instruments to lead to sustainable nature-based tourism. Sustainable tourism is defined as "tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities" (UNWTO, n.d.). The Global Sustainable Tourism Council (GSTC) views it as a form of tourism that acknowledges all impacts, both positive and negative, aiming to minimize the negative impacts, while maximizing the positive ones (GSTC, n.d.). Butler (1999) adds a temporal element to it, related to the verb 'to sustain', and defines sustainable tourism as "tourism which is in a form which can maintain its viability in an area for an indefinite period of time" (Butler, 1999, p. 36). The main elements of sustainable tourism are its focus on the interplay between the environmental, social, and economic spheres and about maintaining viability in an area.

Even though the main philosophies for developing sustainable nature tourism are relatively well-known and implemented, with zoning of nature areas between sensitive conservation areas and more robust visitation areas, and the development of marked trails for different visitor types and visitor behaviours to allow for varied experiences and, as much as possible, a separation of conflicting behaviours, the exponential growth of visitors has further increased local pressures that require additional management approaches. For instance, González-Domingo et al. (2021) note a 77% increase in visits within the Spanish National Park network over the last 20 years. Aside from an objective growth in visitor numbers related to an increased travel propensity and recreational participation, part of the increase has also been fuelled by a post-pandemic interest in nature and at least partly led to 'new' visitor segments experiencing nature areas. Since, in particular, less well-travelled and experienced visitors have a tendency to gravitate towards the most popular and accessible hotspots (McKercher et al., 2012), this has led

to increased pressure on specific routes and park areas. González-Domingo et al. (2021) mention the case of Aigüestortes i Estany de Sant Maurici, where visitors are concentrated in just two concrete sectors (Espot and Boi), Ordesa y Monte Perdido, where visitors concentrate around Ordesa, or Teide, where clear hotspots emerge around the Teide road at Cañada Blanca, Roque García, the cable car, and Pico del Teide, thereby affirming the strong role played here by car visits. Orellana et al. (2012) studies visitor flows in the Dwingelderveld National Park in the Netherlands via GPS technology and found that despite a large number of points of interest in the national park, only a limited number attracted significant numbers of visitors and many places were hardly visited. The authors also confirmed how the largest visitor flows remain near the entrances, with the entrance selected as a starting point therefore largely determining the places that are being visited.

Routing and re-routing to disperse visitors

Routing is a form of visitor management which refers to guiding someone to a (different) place. Routing may refer to using existing infrastructure differently, or to changing or developing infrastructure. In many cases, routing and re-routing might be temporal, in order to increase the efficient use of existing infrastructure and avoid congestion and crowding which can create – besides environmental impacts – negative visitor experiences. Another important reason for (re-)routing visitor flows can be to mitigate ecological pollution and, in particular, prevent visitation of certain areas during breeding seasons.

A routing strategy can therefore be based on improving efficiency and sustainability of existing infrastructure, or on developing new alternatives. Both in case of designing new route networks in nature areas and in case of potentially diverting visitor flows to existing but undervisited areas, there is a need to follow a sustainable planning approach. Firstly, an environmental impact assessment needs to be performed to understand potential impacts on local wildlife, vegetation, soil, and water resources, as well as identifying the most sensitive areas that should be avoided altogether or require special protection measures. Zoning strategies ought to designate areas for different types of activities, ensuring that high-impact activities take place outside, or at the outskirts of valuable nature areas.

Lukoseviciute et al. (2021) specifically reflect on the centrality of visitor experiences in sustainable recreation trail design, which is equally a core concept in the ROS discussed earlier. Effective routing requires both hardware – in trail design and facility provision – and software – in information and education – approaches (Parks & Benefits, 2012). As noted by Orellana et al. (2012) in the case of Dwingelderveld National Park in the Netherlands, visitors concentrate around a few main entrance points and a majority visit the visitor centre, creating opportunities for guiding behaviour through the establishment of new (or improved) entrance areas and information provision. However, at the same time the GPS tracks studied by Orellana et al. (2012) also revealed a diversity in visitor flows which did not necessarily follow the marked tracks and predefined routes.

Taczanowska et al. (2014) came to similar findings when analysing GPS-tracks of visitor flows in the Danube Floodplains National park in Austria, concluding that 61% of recreational use concentrated on designated trails, 21% on non-marked paths, and 18% off-trail use. This reveals that while signposts and well-developed hiking paths can, to a degree, guide visitors, there are limits to its effectiveness.

More recently, studies have pointed to the potential adoption of modern information systems and real-time information to achieve better spreading of visitors based on individual preference and tailored hiking routes. Shaker et al. (2021) tested a smartphone app within Hoge Kempen National Park in Belgium which provided users the possibility of generating user-specific alternative routes taking into account preferences in terms of distance, landscape, level of accessibility, etc. the app further served to provide visitors with basic park information such as captivating points of interest, typical flora and fauna, etc. and served as a means to communicate between park management and visitors. While the initial pilot phase proved the functionality of the app in enhancing the mobility experiences of users, larger-scale testing would still be needed in order to understand the potential of mass market uptake.

Examples of routing and spreading in nature areas and other tourist attractions

Examples of routing and spreading in tourism attractions and nature areas are often linked with (re)developing entrance areas and adopting multimodal mobility choices. For instance, in some parts of the Dolomites, Limited Traffic Zones (LTZs) are used in combination with electric rubber tyre trams to serve as last-mile transportation to protected areas, with a main goal of limiting visitation by personal cars and associated road congestion (Guerrieri & Ticali, 2012). Furthermore, the use of electric trams limits the deposition of damaging chemicals.

Similarly, at the Parc Natural de Cap de Creus in Catalunya, Spain, access of private vehicles has been restricted during Easter, summer, and spring and autumn weekends in order to alleviate pressures and reorganize visitor flows. Instead, shuttle busses now connect the car park with the Cap de Creus lighthouse. Furthermore, wooden bollards on the roadside now prevent cars from parking on the edges of the road, video surveillance cameras control access of vehicles and some access points were closed off due to non-compliance with park regulations (Europarc Federation, n.d.).

At Bosland National Park in Belgium, three main entrance gates (with visitor centres) at Lommel, Pelt, and Hechtel-Eksel are used. Each of the access areas is connected to a route structure and visitor facilities, whereby they each aim to serve a different kind of visitor. Park De Soeverein in Lommel is aimed at sports and recreation, De Grote Hof in Overpelt is more commercially developed and also linked with a cultural heritage site. Finally, Het Pijnven in Hechtel-Eksel combines walking tracks with a cycling experience (Nationaal Park Bosland, n.d.). In Castel del Monte, Italy, entry points to nature areas are linked with

commercial enterprises, including dairy and cheese farms, as these are an attraction and could serve to spread visitors (Buongiorno & Intini, 2021).

Outside of nature areas, the use of parking facilities and alternative (city) entrances are well-known examples of natural visitor dispersion. By locating larger parking spaces in different areas at the city outskirts, and using smart parking guidance systems, visitors coming by car are automatically sorted. This can further be linked to some tangible benefits, such as the Park and Ride (P+R) systems in Amsterdam, offering a discount for people who travel by public transport to the city centre and back. As another example, the new Keerdok parking in Mechelen, located at the edge of the ringway and close to the highway entry/exit offers a free boat shuttle on Saturdays and Sundays to bring people directly to the centre.

Brown et al. (2013) investigated the effectiveness of using such rewards to spread visitors of attractions and theme parks and found that some rewards can effectively lead to spreading. The researchers monitored theme park visitors by means of GPS-enabled devices that send visitors information or other rewards based on location and/or time of day. Examples of the rewards include discounts for underutilized restaurants or merchandise shops, information about wait-times, reservations for shows or attractions, and free merchandise. Discounts are found to lead to more visitation of restaurants and merchandise shops, though for the latter it does not lead to more sales per say. Showing the wait-times does not lead to effective spreading, as visitors were not drawn away from busy attractions. Timed discounts at specific restaurants or merchandise shops show some effectiveness, since twice the number of visitors redeemed their discounts, compared to the control group. Reserved shows or attractions, as well as free low-value merchandise shows little effectiveness, whereas free high-value merchandise shows some effectiveness of spreading visitors to less visited areas.

Apart from spreading visitors within the park, there might also be incentives to link people to other attractions in the region. The Oulanka National Park in Finland is one of the most popular national parks in Finland, with approximately 250,000 annual visits, offering a variety of nature and recreation experiences including hiking, horseback riding, canoeing, whitewater rafting, skiing, snowshoeing, hunting, and finishing. The park offers over 100km of hiking and horse-riding trails segmented to different types of visitors and some accessible by wheelchair. The most famous route, the Bear's Ring Trail stretches about 60km throughout the park, and a smaller section of the trail, the Little Bear's Ring Trail offers a shorter 12km section popular for day hikers. Apart from the Little Bear's Ring Trail, there are four more day-trip trails offering hiking routes ranging from 5 to 12 km. Due to increased visitor pressure on main hotspots, together with regional tourism stakeholders and partners, and funded via a EU project, a new marketing concept, 'Land of National Parks' was introduced to help distribute visitor demands to alternative trails and natural attractions, strengthened by a regional tourism strategy. The central idea behind the marketing concept was to promote five national parks and other attractions in the region,

rather than focusing on Oulanka National Park. On an internal scale, monitoring trail use and implementing trail reinforcements aims to better withstand growth in users (Lyon et al., 2011; Pietilä & Fagerholm, 2016).

Finally, in the context of a cultural attraction, Attanasio et al. (2022) describe the application of a visitor flow management system at the Uffizi Gallery in Florence. In order to avoid long lines outside of the museum and a deteriorating visitor experience for visitors who did not book in advance, a predictive and prescriptive machine learning model was implemented to set up a queue management system, determining the entry time for each visitor. This allows visitors without reservation to access a virtual line, rather than having to wait in-person until a spot becomes available.

Case study: Real-Time monitoring at Zion National Park, USA

Zion National Park in Utah is famous for its massive sandstone cliffs, high plateaus, a maze of narrow and deep canyons, and the Virgin River and its tributaries. The park's highlight is an expansive 15-mile long canyon, averaging 600 meters in depth. Zion Canyon offers hiking opportunities in the 6 to 10 meter wide area known as The Narrows and The Subway. In the area of the Virgin River, swimming is also permitted. In the last decade, the park has seen a significant surge in visitor numbers, attracting more than 5 million visitors in 2021, making it the second most visited national park in the US that year.

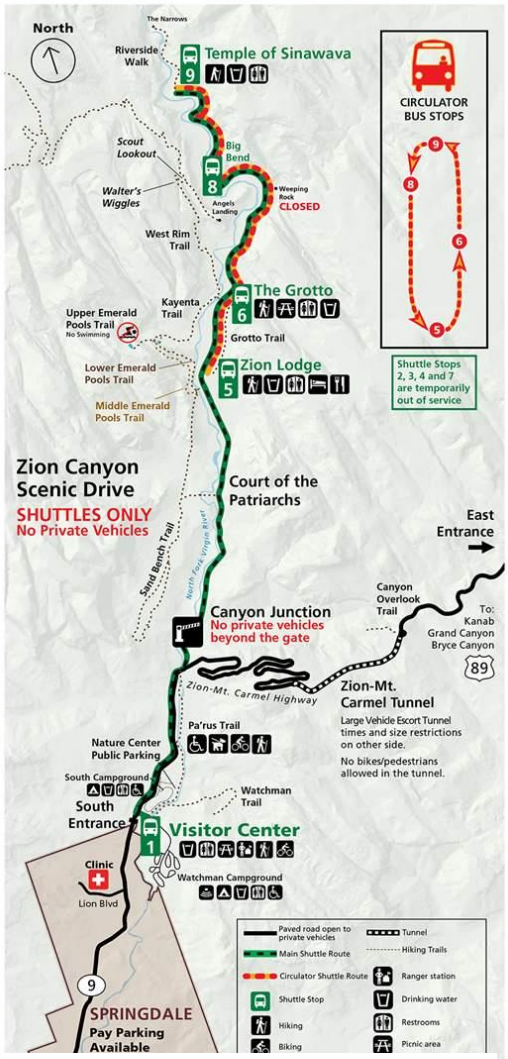

Figure 3. Zion National Park, Shuttle bus map Source: visitutah.com)

Managing crowds at Zion National Park is a significant challenge. Since most visitors come by car, the limited parking lots fill up quickly, increasing traffic jams around the entrance ways. From December through February, visitors can drive their own vehicles along Zion Canyon Scenic Drive, while from March through November, visitors are required to park and use the free hop-on, hop-off shuttles that move crowds into the canyon. Long waiting lines to board the shuttles are common during this time. Similarly, popular hiking trails such as the ones to Angels Landing and The Narrows, which is only accessible by wading through the Virgin River, can become overcrowded, leading to safety concerns and damage to the trails, wildlife, and surrounding environment. On Angels Landing, which allows for a 360-degree view from 450 meter above the canyon, rangers have to limit access to a few hikers a time

due to safety concerns, creating lines that can become several hours long during busy summer days.

Zion National Park has adopted both more conventional and more technologically advanced systems to try to alleviate pressure and more efficiently spread people around the park. First of all, there are two shuttle services: the Springdale shuttle service bringing visitors to the park from Springdale, and the Zion Canyon Shuttle that drives visitors around through the canyon, offering nine stops in a hop-on, hop-off system. The shuttle system is integrated with real-time monitoring of visitor flows to adjust frequency and capacity based on current visitor demands. Furthermore, digital information boards at visitor centres and shuttle stops provide real-time updates on trail conditions and crowd sizes, which can help to nudge visitors towards alternative hikes and attractions. Furthermore, the real-time monitoring is linked to a mobile app which, again, offers visitors information on trail conditions, parking availability, shuttle schedules, and areas of the park experiencing high visitor density (Upchurch, 2019).

Case study: Capacity limits, pricing, and sustainable transportation at Triglav National Park, Slovenia

Triglav National Park covers practically the entire Slovenian part of the Julian Alps, covering an area of 840 km². The park offers 25 entrance points via road, plus many additional routes via mountain paths. The National Park was officially founded in 1981 and is managed as a public institute, even though various parts had already received protection since 1924. Within the borders and its difficult-to-access mountainous terrain, many natural and historical sites can be found which attract thousands of tourists each year. Famous natural attractions are the river Soča, the Boka and Kozjak waterfalls, Tolmin Gorge (with over 90,000 visitors in 2021), Vintgar Gorge (with over 200,000 visitors in 2022), and Lake Bled. The Triglav National Park also boasts a ski centre, Vogel, popular for winter tourism (Triglav National Park, n.d.).

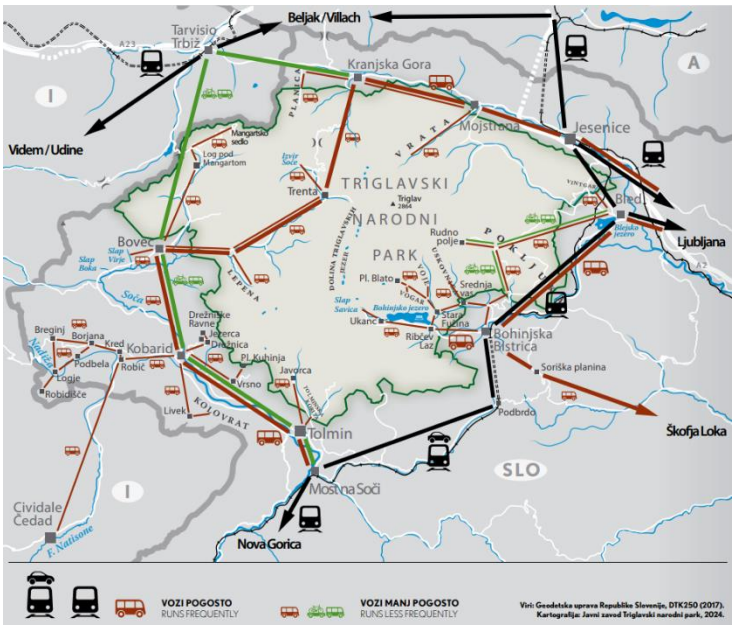

Figure 4. Sustainable mobility (Source: Triglav National Park, n.d.)

While the park is generally accessible free of charge, inside the park four natural attractions charge an entrance fee: Vintgar Gorge, Tolmin Gorge, Mostnica Gorge, and the Savica waterfall, due to their external management (Buys, 2022).

The nature area suffers from imbalanced visitor concentration in a few prime attractions. Management issues are exacerbated by the fact that Tolmin Gorge and Vintgar Gorge were already natural attractions managed by a local tourist organization prior to the establishment of the national park and they therefore fall outside of the jurisdiction of the park management. The main consensus that exists in this relationship is that the tourist organizations managing these attractions must ask for nature conservation consensus issued by the Ministry of Environment and Spatial Planning and the management of the Triglav National Park (Buys, 2022).

In order to be able to reduce the negative impact of visiting nature, the management of the Triglav National Park developed a methodology to determine the carrying capacity of natural attractions, taking into account the length and width of the path, the duration of the visit, weather conditions, security concerns, and nature conservation elements. Tolmin Gorge imposes a maximum capacity of 200 visitors per one-hour timeslot, aiming to more evenly spread visitors across the day via an online reservation system and flexible pricing. During summer periods, when the gorge is accessible from 09:00 to 18:00 this therefore amounts to a maximum of 1,800 daily visitors. Similarly, Vintgar Gorge aims to limit simultaneous visitation to 270 visitors at a time, managing and measuring visitor flows through timed entrance tickets with a fixed

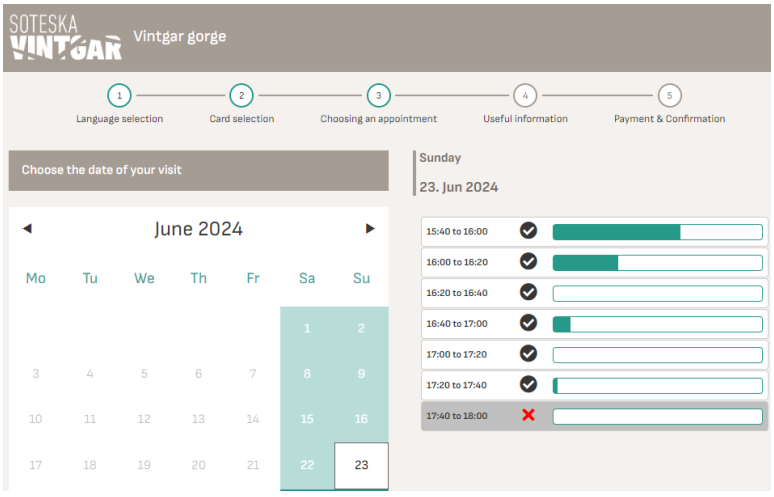

Figure 5. Booking module (Source: Vintgar Gorge, n.d.)

pricing (Buys, 2022). The booking module of Vintgar Gorge uses 20-minute timeslots and allows prospective visitors to view the amount of visitors already expected on specific dates and times.

Furthermore, to avoid issues with car traffic and private parking, the organization set up an agreement with a local company to use the company car park during the tourist high season and bring tourists to the gorge via eShuttles. At the level of Triglav National Park as a whole, establishing capacity limits is linked with providing information on various modes of sustainable transportation and adequate park infrastructure to guide people to less vulnerable areas of the national park via alternative modes of transportation. A significant intervention in this regard is the Zuugle.si search engine for hikes that are reachable by public transport.

2.2. Modal shift: determinants of mobility behaviour to and within nature areas

Within MONA project, the Pilot A group, bringing together National Park Utrechtse Heuvelrug (the Netherlands), Grenspark Kalmthoutse Heide (Belgium) and National Park Montagne de Reims (France), is specifically looking into the encouragement of the modal shift from car use to more sustainable mobility options. Within MONA project they are investigating how train stations can be further used as "green entrances" to the nature areas and researching the possibilities of soft mobility options facilitation via mobility hubs. Modal shift is closely related to the determinants of the mobility behaviour to and within nature areas.

Determinants of mobility behavior

Mobility behaviour refers to the decisions people take in relation to a trip and "...is influenced by a myriad of factors..." (Lopez & Wong, 2019, p.122). Mobility behaviour is based on utility maximization theory, which argues that individuals pick the option that yields the highest utility. This utility is based on travel time and travel costs, amongst other variables (McFadden, 2000). Generally, transportation research distinguishes two main groups of determinants influencing the perceived utility, which have different denominations:

- Objective versus subjective factors (Scheiner & Holz-Rau, 2007),
- Hard versus soft factors (de Vos et al., 2012), and
- Physical versus social (psychological) contexts (Lopez & Wong, 2019).

Objective factors, for example, determine the available behavioural options (Lopez & Wong, 2019). If no sustainable options exist, cars will be used, despite someone having a high motivation to use sustainable modes. Conversely, if several sustainable options exist, but people experience restrictions, such as preferences or habits of using a certain mode (e.g., car ownership), or physical limitations, less sustainable modes could still be opted for.

Götschi et al. (2017) add to this dimension a political factor, which mediates between the physical and the social (Figure 6. PASTA framework for active travel behaviour (Source: Götschi et al, 2017)

6). In their PASTA framework (part of the project called 'Physical Activity through Sustainable Transport Approaches'), the authors make use of a nested layout, which shows macro-level influences from a city, region, or country level up to individual decisions in the context of an activity or trip. They do show that travel choices depend on the combination of the existing policy, built environment characteristics, influences of community, peers, household and individual characteristics and preferences.

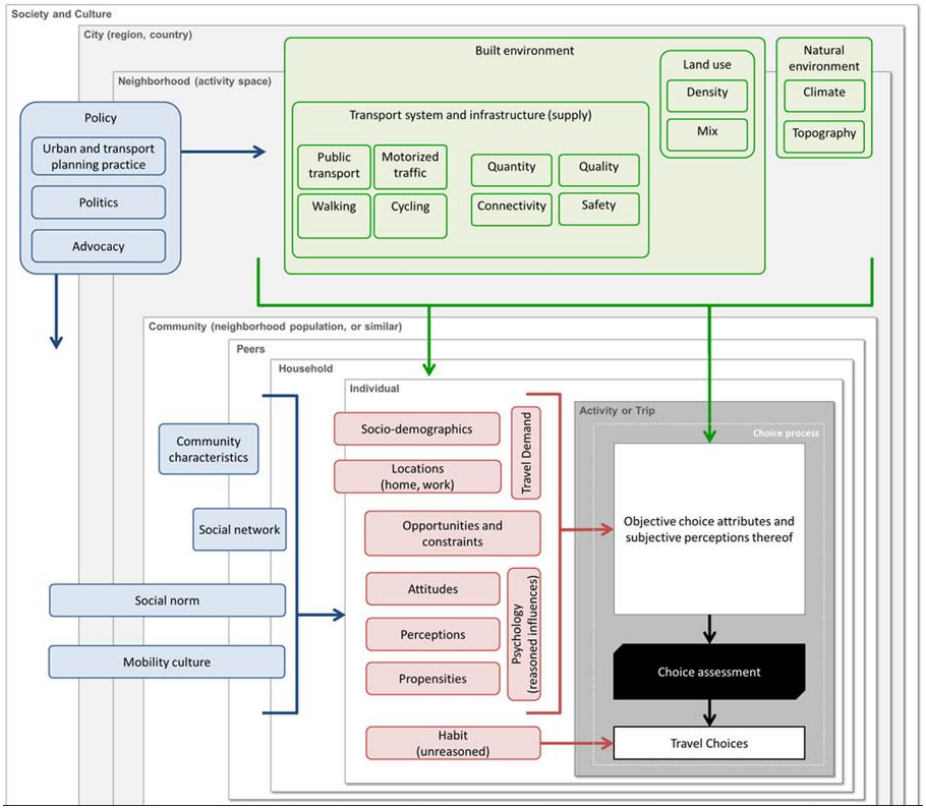

Figure 6. PASTA framework for active travel behaviour (Source: Götschi et al, 2017)

Cervero & Kockelman (1997) identify different dimensions influencing mobility behaviour, from the built environment perspective

- Density,
- Diversity, and
- Design (3Ds)

Density refers to the population or employment density (and consequently the infrastructure density), diversity refers to the variation in land use (e.g., availability of recreational areas), and design refers to the availability of alternative transport modes (e.g., bicycle lanes). These factors tend to differ between urban and more rural areas. In rural areas, the population and recreational activities (related to density and diversity,

respectively) are scattered, distances (related to density) tend to be larger, which means that local mobility is often car dependent (Tomej & Liburd, 2019).

Moreover, various socio-demographic factors have been found to influence mode-related travel decisions: age (Lopez & Wong, 2019; Le-Klähn et al., 2014; Kattiyapornpong & Miller, 2009; Hunecke et al., 2007), income (Kattiyapornpong & Miller, 2009), (family) life cycle (Kattiyapornpong & Miller, 2009), and possession of a driver's license and car (de Vos et al., 2016; Hunecke et al., 2007). For example, according to Guhneman et al. (2021), the ageing population is rapidly growing and this transport user group is "characterised by a particularly high degree of motorization or share of driving license ownership, has a strong affinity for cars and is also less convinced of the advantages of alternative modes of transport". Therefore, this transport user group is hardest in switching to climate-friendly forms of mobility.

While above mentioned are mobility behaviour determinants that are relevant for both commute and recreational mobility, tourism and leisure mobility behaviour has its own specific characteristics that need to be taken into account. Peak hours may differ between the types of mobility, as well as familiarity with traffic rules. The seasonality impact is generally higher with recreational mobility, distances tend to be longer, travel parts larger, and more dependent on weather conditions (Pijpers, 2024; Schmücker & Grimm, 2024). Surveys conducted within recreational areas in and near Utrecht did illustrate that the main reasons why visitors would not travel to the nature area by bike, train, bus or by foot were, depending on the areas (Kantar Public, 2023):

- Area is located too far away;
- The travel time costs too much time;
- Not practical, considering composition of the travel group and/or number of luggage (things) to take with;
- Absence of train station/bus stop in the area;
- Large availability of the parking space at the location;
- Overall habit of using car for all the trips.

Mobility preferences have an impact on the mobility behaviour to and within nature areas as well. Anable (2005) developed a widely adopted typology for mobility users, based on their attitudes towards car use, alternative use, the environment, and green behaviour. User segments differ from each other in the level of current and projected car use. Anagnostopoulou et al. (2020) simplified this typology by using three segments: drivers, potential non-drivers, and non-drivers. Within each segment, users can be motivated by convenience or green reasons, which could contradict their actual behaviour. For example, drivers could have green attitudes, but could be limited by a lack of alternative options, whereas non-drivers could lack green attitudes, but do not own a car, therefore do not use a car.

Conducting research on the modal shift of walking groups from car travel to bus and train, Davies et al (2015) developed a framework of factors influencing the decision-making process of walking groups towards certain transportation modes. This framework, to a certain extent, can be applied to individual and smaller group travellers (Figure 1. Visitation effects on ecological park resources (Source: own work)

Figure 77).

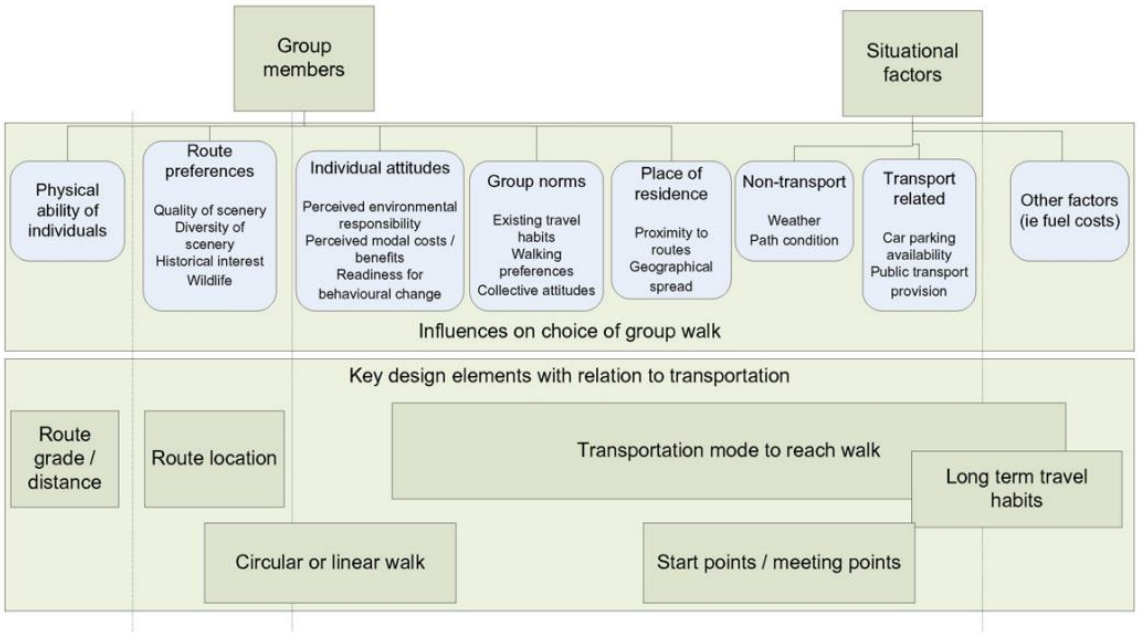

Figure 7. Factors affecting the design process of organised group walk in relation to transportation (Source: Davies et al, 2015)

The top half includes influences relating to the groups themselves or situational factors based on the environment or transport provision. The bottom half of the scheme includes key design elements influencing route choice of walking groups.

Modal shift to sustainable travel modes in tourism

Modal shift relates to the change from one transport mode to another (Rodrigue, 2020). In the literature, the 'shift' in this concept is mostly used as a movement towards the use of more sustainable modes (e.g. Shaker & Hermans, 2021; Scuttari et al., 2019; Orsi, 2015). Guhnemain et al. (2021) define modal shift in tourism as "the transfer of arrival and departure traffic as well as local tourism mobility by private car to environmentally more climate friendly modes (e.g. public transport, cycling, walking)". In case of mobility to, from and within nature areas, that means that it is necessary that motivations of people to travel to nature areas and their motivations to use more sustainable travel modes are balanced with other determinants of the mobility behaviour. As Fearnley (2013) noted, a modal shift should be looked at from a between-mode perspective (from-to) rather than only from a within mode (share of trips per mode), as increases in shares of bus trips could for example be caused by a decrease in pedestrian trips. This would then be

counterproductive with sustainability goals, such as emissions and noise reduction. Overall, the requirements and intrinsic motives of tourists need to be met, sustainable means of transport should be available for the entire trip chain, including on-site mobility, the information should be easily accessible and corresponding attractive price offers are created (Guhenman et al., 2021).

From the supply side it would entail an act of steering demand towards different transport mode(s). This steering of demand can be done by playing into comparative advantages, such as costs, capacity, time, and reliability (Rodrigue, 2020). Overall, acknowledging the high role of car in recreational travel, OECD (2000) defines the following factors underlying this car-dependency in leisure:

- Supply, characterised by the lack of alternative modes of transport to recreational facilities and lack of necessary infrastructure (e.g. cycling paths);
- Price, considering the recreational activities are often group activities, tending to make car travel more attractive, especially for longer journeys;
- Attractiveness of alternative travel modes, for example in terms of comfort and travel time;
- Travel information, considering that getting to the unknown destination by car only requires proper reading of the maps and road signs, while travelling by public transport or train involves interpreting and obtaining of bus/train schedules;
- The lack of flexibility in train or bus provision.

Seljanko (2024) concludes that in leisure to nature areas, in general, the groups that rely the most on personal cars are: visitors who engage in sportive activities; people who travel in large(r) groups (e.g. families; large walking groups; excursions) and the visitors that travel long distance to nature areas.

Next to determinants of the mobility behaviour, (in)accessibility of the nature areas itself plays a major role in the sustainable modal shift to those destinations. Feng (2023) refers to accessibility "to the ease of using a given transportation system to get from a given area to a place of activity". For him, "tourism accessibility is the main benchmark to measure the convenience of the interregional tourism transportation system". Accessibility is subject to several factors: e.g. dispersed and often rural geographical location, travel time, lack of sufficient transport provision, poor quality of existing transport provision, lack of information about alternative travel options (Ram, 2020); Dickinson & Robbins, 2008). For example, the research of Davies (2015) shows that perceived difficulties caused by transport to and from the start or end of the walk were the most significant barrier to linear walks. He adds that "these difficulties were amplified in rural locations where public transport services were sometimes scare" (Davies, 2015). Although cycling routes have seen an increase in popularity, research of Buongiorno and Intini (2021) shows that tourists revealed that the lack of actual cycling was due to the perceived difficulty of combining it with forms of public transport, such as the train or the bus. Accessibility from

terminals/vehicle stops to tourists locations is also considered as one of the key indicators that support tourism (Hussain et al, 2023).

Guhneman et al. (2021) argue that travel patterns between the start and the destination of the tourism trip determine overall mobility requirements on arrival, departure and on site, as well as the transport effort and mode choice.

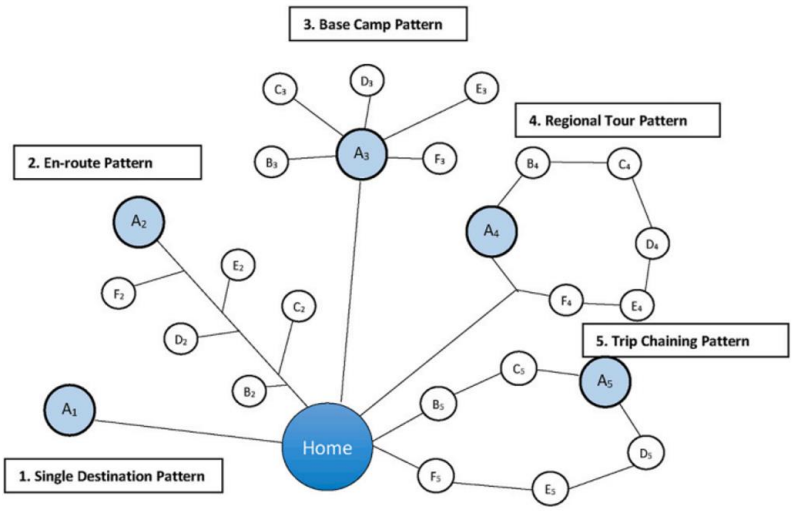

Figure 8. Different travel patterns of a tourist trip (Source: Guhneman et al, 2021)

As example, the authors mention that the car offers significant flexibility advantages over public transport in particular for trips with multiple destinations and "en-route" pattern, while the travel patterns with a high amount of travel within the destination (single destination pattern; base camp pattern, regional tour pattern), integration with local travel provision is important (Guhneman et al., 2021). Understanding of the overall travel patterns of the nature area visitors may allow for the development of more efficiently targeted solutions for the modal shift. For example, as research of Davies et al. (2015) illustrated, while there were no concerns about train walks between stations, for bus walks, the bus journey outward and then walk back were advised. The barriers for using the buses for linear walks included: inaccessibility, potentially poor frequency and reliability.

The availability of public transport is often indicated as an important factor in order to reach a modal shift. Frequently, nature areas are located in the peri-urban and rural areas, which, as such, are often characterised by the limited offer of the public transport. Hussain et al (2023) note that "the lack of unified mobility policy in rural areas is a result of low population density", which implies a low number of users. Research of Davies et al. (2015), investigating possibilities of the modal shift for the walking groups to nature shows that many hiking groups to nature areas wanted to take their walks on Sundays – a weekend day where public transport services are even more infrequent, particularly in the morning. Ram (2020) demonstrates that lacking provision of public transport in rural

areas leads population groups not owing a car to visit Israeli nature parks significantly less.

Considering that natural areas within MONA pilot A are located close to the train stations, there is a specific interest to look at the potential of modal shift from car to rail, encouraging visitors arriving (an departing) to the nature areas by train. Blancheton and Marchi (2013) define "tourism and leisure trips that use railways to transport tourists (whatever the reason for the move)" as rail tourism, highlighting its heterogeneity. Considering specific motivations of using the rail for tourism, they identify the following dimensions of analysis: the passenger interest in trains (the reasons that travellers take high-speed train would be very different from those of taking tourist trains); the consideration of speed.

Tourism railway lines would be those exclusively dedicated to tourism practices: e.g. panoramic railways, amusement railways, "living museums" railways. Recently there is an increasing attention from the European Union on the revival of the regional railways that are often connecting large urban centres with smaller communities and are connecting different communities. Those railways are often the ones providing connections between large urban centres and rural and nature areas. There are a large number of regional lines that lack cost efficiency, thus being closed or are at risk of being closed. Flipo et al. (2023) provide an example of SNCF, the French railway, that "has turned its back on the small rail lines", with rural regions not being a priority for the provision of the service. Moreover, traditional focus of railways on commuting results in the fact that a majority of maintenance and repair works are scheduled on the weekends, which are the days for the most recreational activities.

Summarizing large body of the literature looking into the barriers of using the rail for leisure and tourism activities, Blaney et al (2012), combine those in three categories (*Table 1*Table 2).

Table 2. Barriers to rail use in tourism travel

Factor Type	Explanation	Examples
Hard Factors	Factors that affect all passengers, with varying elasticities	Time, money
Soft Factors	Factors that are of varying importance to different travellers, trips and places	Station facilities, comfort, information provision
Complementary Factors	Factors that relate to the impact of lifestyle choices and the wider economic and cultural background of a person	Habits, age, culture

Source: Blaney et al. (2012)

The choice between making a trip by car or train is often based on door-to door travel time: while trains are a quick and generally convenient way to travel between railway stations, transport to and from the stations lengthens the trip considerably and thus affects the modal choice of travellers (De Boer et al., 2011). Delays and cancellations of train and public transport services were seen as disastrous for the walks .

Roos et al. (2018) highlight the importance of railway stations in constructing and enabling "vibrant places and social gathering places", playing a role of gateways to the cities and nature/recreation areas. For that, they need to include the following key principles:

- Efficiency, supporting station functionality,
- Integration, providing passenger flows,
- Safety and security,
- Place making, station design and siting character
- Connectivity, the accessibility of stations and interchange ability.

Similarly, bus stops can be seen as important gateways to walking in the nature areas. For example, the "groene haltes" project of Visit Brabant, encouraging the start of beautiful walking routes in nature areas from designated bus stops (Vanuit de bus de natuur in | Bravo).

Examples of solutions for modal shift to, from and within nature areas

A variety of interventions are possible to encourage more sustainable travel modes to and within nature areas. To tackle the issues of high dependency on car travel, different nature areas have tried out different measures, that can be classified as either "push" or "pull" measures, or combination of those (Sedalko, 2024). "Pull" measures are those that improve attractiveness of other modes than the car, while "push" measures are those that penalise car use.

Robbins (2018) identifies the following most common "pull measures":

- Establishing more frequent and cheaper public transport options;
- Establishing new and innovative services specifically designed for tourists;
- Developing transport as a visitor attraction;
- Combine transport use and tourism activities;
- Park and Ride.

According to the Europarc Federation (2015), for travel to the national parks, some best practice measures include:

- Raising public awareness by means of collaborating with train operators in the form of advertisements on train carriages;
- Operating buses more frequently during weekends and public holidays;
- Operating buses that are capable of transporting bicycles (which also stimulates sustainable transportation within the protected area);
- Accommodating tourist information (centres) in train stations;
- Providing rental bike facilities nearby train stations.

The relevance and efficiency of these solutions depends on the density of the mobility network surrounding it.

OECD (2000), suggests that "provision of co-ordinated public transport services as supply chains may improve competitiveness", for which the following would be necessary:

- Adjusted timetables allowing trains and buses to link up;
- Trains and buses are made compatible in terms of comfort;
- Train to bus through-ticketing is made available.

With growing importance of cycling, cooperation between cycling and rail operators can bring additional advantages in promoting sustainable tourism. For example if you travel by rail to Neusiedl lake in Austria and decide to leave your bike at home, you can use any ÖBB ticket to rent a bicycle at Bucsis Bicycle Rentals, located right next to the Neusiedl/See train station, at a reduced rate.

Inclusion of the free public transport in the locally available tourism card packages, can also be seen as form of "pull measures", encouraging tourists to locally use public transport. For example, in most Swiss destinations, by booking of at least one night's stay in the hotel, guests get a guest card (or can buy one at a discount), allowing to use public transport for free and to benefit from discounts on numerous attractions and activities (Guest cards and tickets | Switzerland Tourism (myswitzerland.com)).

> *"When a guest books holidays in the hotel, then the hotel asks the guest whether he or she wants to get a free public transport ticket, allowing to travel with the public transportation network. We estimated the effect of this offer on travel mode choice and found out that between 10 and 15% of the guests switched their mode from private car to public transport due to this offer". (Researcher at University)*

For example, Rocky Mountain National park in the US provides regular two daily shuttle bus services to destinations located along Bear Lake Road, from the general Park & Ride location, thus reducing the usage of the car within the nature area itself. At the Park & Ride Transit Hub, passengers can transfer between the two different shuttle routes (RMNP Shuttle Routes (U.S. National Park Service).

Robbins (2018) identifies the two main categories of the "push measures": parking control and prevent or limit car access, which can be organised, for example, by the introduction of toll roads and closure of roads.

Table 3. A hierarchy of measures to influence the travel behaviour of visitors to National Parks

Measure	Description	Used in British National Parks?	Expected effectiveness reducing car use	Expected effectiveness in reducing traffic nuisance
Road closure	Access to motor vehicles prohibited	Yes	High	High
Rationing—quantity	Access prohibited once a set number of vehicles have arrived	No	Medium	Medium
Rationing—road use charging	Charging road users to use certain roads, most simply through the use of a cordon	No	High	High
Speed limits	Speed limits below the norm for the type of road	Yes	Low	Medium
Parking control	Limiting provision, charging	Yes	Low	Low
Traffic calming	Road capacity appears or is reduced to slow traffic	Yes	Low	Medium to High
Route hierarchies	Advisory routes to keep vehicles on appropriate roads	Yes	Low	Medium
Signposting/gateways	Use of signing to increase awareness of special nature of the area	Yes	Low	Low
Awareness campaigns	To inform public of problems associated with traffic	Yes	Low	Low
Public transport publicity	Timetable etc information	Yes	Low	Low
Footpath enhancement	Improving signing, publicity etc	Yes	Low	Low
Enhanced provision for cycling	Cycle hire, cycle routes etc	Yes	Low	Low/medium
Enhanced public transport provision	Improving frequency, reliability, coverage	Yes	Low/medium	Low/medium

Source: Steiner (2000)

A combination of "push and pull" measures is very common as well: e.g. combination of shuttle bus services with road closures and park & ride facilities. May & Bristow (1995) consider that these measures can only work effectively in combination, such that restrictive measures complement each other and attractive alternatives are offered as in the "package approach" . Holding et al. (1998) go further concluding that "pull" measures alone are ineffective by themselves and "push" measures might be essential to achieve the real modal shift.

Recent technological developments brought variety of smart mobility solutions to the market. According to Hussain et al. (2023), "smart mobility and smart tourism have a strong mutual relationship in rural communities, where transport and mobility options are often limited and accessibility poses issues to tourist sites". Smart mobility services (e.g. on demand transport, car-sharing) make it easier for tourists to access and explore rural areas and landscapes, increasing attractiveness of tourist destinations, which further increase demand for new mobility solutions and infrastructure improvements, benefiting tourists and residents. These developments are also supported by current trends of decreasing car ownership in some European cities e.g. decreasing number of young adults possessing a driving license and car-free households, using car-share and rental car offers for leisure and tourism activities (Guhneman et al., 2021). For example, the Nockmobil in Nockberge mountains acts as the call-and-collect, demand-focused taxi, providing a flexible, green alternative to private car (Das Nockmobil - Alles perfekt vernetzt aus einer Hand).

Autonomous vehicles are one of the smart mobility solutions being increasingly trialled within tourism in general (e.g. airport shuttles and sightseeing tours) and, as feeders for the first and last mile for recreational activities and destinations. For example, the Terhills Resort in Belgium replaced the conventional electric shuttle bus, which was under-used and costly to operate, to the EasyMile self-driving passengers shuttles, daily connecting the various attractions on the ground. This autonomous shuttle is for free and can accommodate up to 12 people, including wheelchair users, on the route of 2.5 km, connecting the main resort, on-site hotel, as well as future walking and cycling bridge over a large lake (Terhills Introduces Autonomous Shuttles: The Mobility of the Future – Terhills). Autonomous shared vehicles or minibuses could make public transport cheaper, more flexible and more attractive (Soteropoulos et al., 2019).

Information and communication technologies are increasingly supporting the shift to sustainable mobility: technologies for ticketing, information and multimodal solutions, technologies for real time information. Online booking platforms and smartphone apps make it easier and, sometimes cheaper, for travellers to organise and book door-to-door travelling to recreational activities, including in rural areas. For example, the TrainSplit app, which is not only reducing the cost of rail travel to its passengers but also actively promoting the train accessible hikes (About | TrainSplit).

A holistic approach and well-developed destination strategy is essential to ensure a successful approach to modal shift. For example, the "Alpine Pearls" network, an association of tourist communities in the Alpine region has an established goal to make it possible to discover and experience the region car- free (Alpine Pearls – a car-free holiday in the Alps (alpine-pearls.com)). Putting a "car-free" holiday in the centre, they are providing the guests with a full information platform on which nature areas in the Alps can be reached car-free, what people need to know about car-free holidays in Italy, Austria, Switzerland, etc., and how to get a free mobility destination travel card.

Another example of the latter is the Burgenland Card (The Burgenland Card (freistadt-rust.at), provided at certain hotels next to Lake Neusiedl. The card entitles the visitors to a range of free activities alongside the lakes (e.g. free admission to lakesides, free concerts and museum visits, free admissions to swimming pools, free guided tours, etc.), including free public transport in the area.

In case the nature area is located close to the train station, its integration into the broader offer of the railway products can bring additional incentives of modal switch to rail. For example, Scenic Rail Britain, offers a wide range of thematic rail routes, not only connecting historic cities, but also countryside and national parks (Picturesque countryside | Scenic Rail Britain). It not only promotes travel by rail, but also encourages transport to and from train stations by sustainable travel modes, ensuring that the public transport offer, as well as walking and cycling possibilities, are prioritised to car access at the "getting to and from the station" website section. Not only information about concrete routes is provided, but also information on timetables, railcards and passes, group travel

and other practical information to facilitate access to nature and rural areas by train are provided through one platform. The similar information, but at a lesser extent, is also available at the Rail Europe website (Plan to visit the best national parks in the UK by train (raileurope.com)).

Case study: autonomous shuttle bus at Wright Brothers National Memorial and Yellowstone National Park, US

The National Park Service (NPS) cares for the more than 400 national parks in the United States. It partners with local communities to assist in historic preservation and the creation and maintenance of recreational spaces. In 2021, with the support of the US Department of Transport (DOT) Volpe Center the NSP has launched two automated shuttle pilots at recreational public lands:

- The pilot at Wright Brothers National Memorial, the Connected Autonomous Shuttle Supporting Innovation (CASSI), ran from April to July 2021.
- The pilot at Yellowstone National Park, The Electric Driverless Demonstration at Yellowstone (TEDDY), ran from June to August 2021.

To date, most automated shuttle pilots have been held in urban areas, and the remote setting at Wright Brothers and Yellowstone provided NPS and industry leaders with an opportunity to assess the suitability of these technologies for use in public lands. In early 2020, the NPS applied for and received a grant of $600,000 from the US Department of Transportation (DOT) Technology and Innovation Deployment Program to support these two automated shuttle pilots. The goal was to evaluate how automated, electric vehicle technologies perform in public lands, guide long-term decisions about transportation in parks, enhancing access and encouraging green, car-free trips, identify and overcome unforeseen regulatory and organizational barriers of emerging mobility technologies.

CASSI

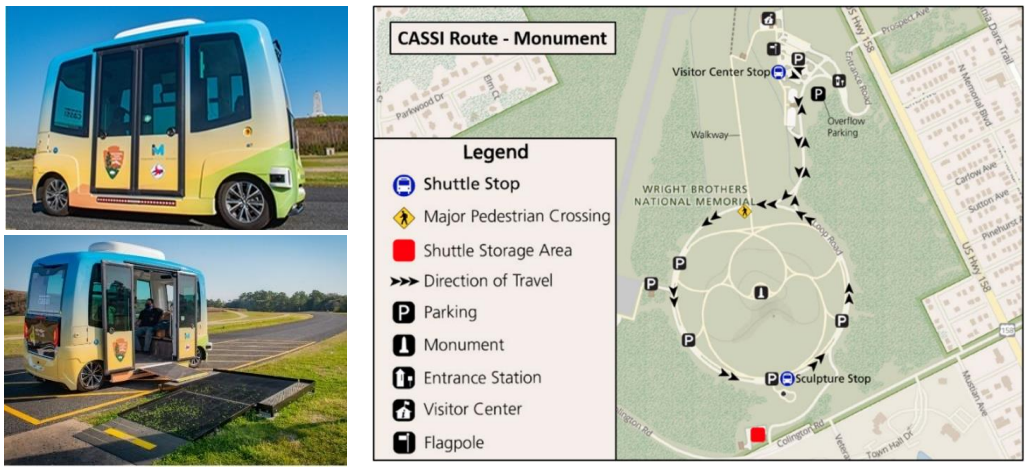

Figure 9. CASSI vehicle and route (Source: NPS, 2022)

The Wright Brothers pilot was conducted in partnership with the North Carolina Department of Transportation. One automated vehicle was operated by Easy Mile (shuttle provider) and Transdev (operator), five days a week (Monday – Friday), from 10.00 am to 16.30 pm (with one break). The vehicle was running on one route of 2.4 kms approximately, having two intermediate stops, bringing visitors from the main parking lot near the Visitor Centre onto Wright Brothers Memorial Loop, and to the Wright Brothers Monument. Considering the pilot ran during COVID-19, the shuttle was limited to a maximum of six occupants (i.e., five passengers plus the safety operator). NPS staff placed sandwich board signs to indicate where shuttle stops were located and to provide guidelines and information about riding the shuttle: the shuttle ran on a 15-minute schedule when operating; Ridership on the shuttle was first-come, first-served; face masks requirement (in compliance with COVID-19 safety measures). Next, localisation signs were installed along the shuttle route to service as known location markers.

TEDDY

Yellowstone National Park covers nearly 3,500 square miles and is one of the largest and most popular national parks in the United States, hosting more than four million annual visitors in recent years. It has many attractions, including its wildlife (e.g., bison, grizzly bears, and wolves), hydrothermal features (e.g., geyser sand hot springs), and other geological features such as mountains, valleys, waterfalls. Just north of the Grand Canyon of the Yellowstone Upper and Lower Falls sits Canyon Village, which has a large horseshoe-shaped parking area, the Canyon Visitor Education Center, an adventure gear store, a general store, the Canyon Eatery, lodging accommodations and camping sites.

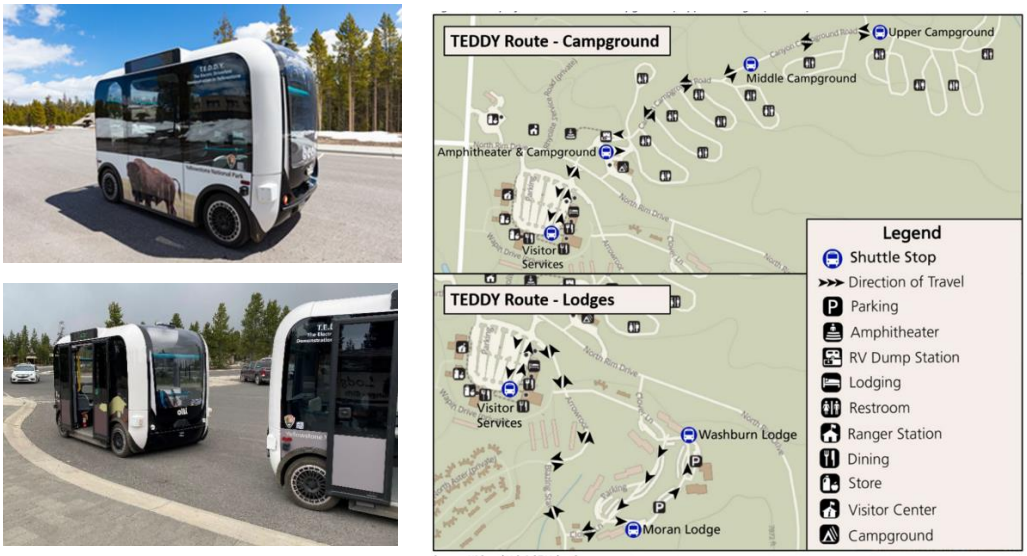

Figure 10. TEDDY vehicle and route (Source: NPS, 2022)

The Electric Driverless Demonstration at Yellowstone brought visitors to and from the lodges and campground in Yellowstone's Canyon Village. Two shuttles, operated by Beep were running seven day a week between 7:00 am and 9:00 pm, with two breaks. Vehicles

were operating on two different periods and on two different routes, performing three to four stops and covering, 2.4 – 2.5 kilometres per route. The first route provided transportation between the Canyon Village Visitor Services area and the lodge area; the second route provided transportation between the main parking area and the campground. The maximum seated capacity was eight passengers plus the operator, who stood while operating the vehicle. Many site modifications were made to enable operation of the shuttle within the national park: adding or changing some directional and safety signage to accommodate the shuttle route; adding shuttle stop signage; installing traffic stop signs along both routes; adding equipment to help the shuttle more accurately determine its location, etc.

The results from both pilots are summarized in the table below.

Table 4. Overview of main TEDDY and CASSI pilot results

Category	Yellowstone National Park (TEDDY)	Wright Brothers National Memorial (CASSI)
Operator	Beep	Transdev
Vehicle	Local Motors Olli	EasyMile EZ10
Number of Shuttles	Two	One
Operating Days	Seven days, Sunday–Saturday	Five days, Monday–Friday
Service Day	7:00 am – 9:00 pm (with two breaks)	10:00 am – 4:30 pm (with one break)
Planned Hours per Day	9 hours	5.5 hours
Number of Unique Routes	Two routes	One route
Route Miles	1.5 miles / 1.6 miles	1.5 miles
Number of Stops	Three / four	Two

Source: NPS, 2022

The evaluation of the pilots used a mixed-methods approach, relying on quantitative statistics, survey data, and qualitative interviews with relevant stakeholders: e.g. Monthly Disengagement Report; Weekly Operator Reports; Monthly Operational Reports; Rolling Visitor Survey Responses; Visitation Numbers Report; Deployment Dairy; informal interviews with park staff and others. Within the CASSI pilot, from effectively scheduled 64 days of operation, the shuttle ran for 46 days with complete services; 8 days with partial service and complete suspension of 10 days (due to battery issues). Within the TEDDY pilot, from 84 scheduled days the vehicle was 74 days in actual operation. However, due to multiple service suspensions caused by shuttle battery issues, weather conditions, and shuttle incidents, there were only 38 days where both shuttles ran in full service for the entire day. The average speed of the CASSI shuttle was around 8.4 km/h and the maximum speed reached was 15.3 km/h. In total, the shuttle took 809 roundtrips and carried 3,380 passengers, having approximately 4.2 riders per roundtrip. In total on the two routes 2,544 trips were taken for the TEDDY shuttle, carrying 10,057 passengers, with the average number of riders per day per shuttle at 85.8 and 3.9 passengers per single trip.

Overall, the visitors had a good experience with the CASSI shuttle (85% from 273 responses), feeling safe taking it (86%). For TEDDY shuttles 78 percent (from 222 responses) reported good experience and 98 percent safe experience of vehicle driving.

CASSI survey results indicated that the majority of people rode it solely for a "fun experience" (62 percent from 273 survey responses), with only a small percentage riding it specifically to get to their destination (7 percent) and the remainder using it for both purposes (32 percent). Within TEDDY pilot, 83 percent has used it for fun; 2 percent to reach the destination and 13.3 percent for both. The survey results indicated that visitors would like to see more driverless shuttles in National Parks: over 94 percent of respondents either "Somewhat" or "Strongly Agreed" with this statement. Through staff interactions with visitors it was observed that some visitors came to the Wright Brothers National Memorial site specifically to ride the shuttle.

During the pilots it was discovered that weeds growing within 1.5 feet of the roadway interfered with the lidar sensors on board of the shuttle, causing the shuttle to repeatedly slow, stop, or disengage at multiple points along its route. While during the pilot, park staff mowed the grass as frequently as every three days to address the issue, it was noted that this frequency of mowing is not sustainable in the long term.

Main parking area, where there was regular interaction with tour buses and vehicles with trailers, represented the main driving challenge, accounting for almost 23 percent of all vehicle disengagements (e-stops, soft stops, and circumventions). Overall, multimodal conflicts were occurring when drivers were attempting to pass the shuttle as it was stopping for the pedestrians. Weather conditions, specifically rain and storms did have an impact on the vehicles performance.

Some main learnings, from both pilots, going beyond the regular automated vehicles technology pilot results and specific to the operation in nature parks:

- Ensure that replacement parts are readily available and that maintenance staff can quickly address technology malfunctions;
- Develop a plan for service interruptions and be prepared to address visitor confusion, which may result from unexpected vehicle behaviours;
- Improve the quality and placement of information provided at vehicle stops;
- Expect disruptions caused by environmental conditions and plan for additional landscape maintenance;
- Balance visitor experience and transportation needs.

2.3. Nudging sustainable mobility behaviour to and within nature areas

Within MONA project, Pilot C group, bringing together National Park Montagne de Reims and National Park Scarpe – Escaut in France and Tourismus Zentrale Saarland, Germany, are specifically focusing their activities on nudging for the purpose of sustainable mobility behaviour. The MONA project analyses visitor flows and visitors (mobility) behaviour in those parks and thereby aims to investigate nudging techniques available to manage visitor flows with a perspective of ensuring, for example, sustainable mobility behaviour to and within nature areas, better trail conservation, nature education and litter reduction.

Nudging in its different forms

The goal of behavioural economics is to understand how psychological biases and cognitive processes influence people's decision-making, particularly in financial contexts. By studying these patterns, behavioural economists can predict and influence behaviour. They often use these insights to design interventions, such as nudges, which subtly guide individuals toward more desirable choices without limiting their freedom, benefiting both individuals and society (Reisch & Zhao, 2017). One of the main objectives of behavioural economics is to understand how psychological biases (nudges) can be effectively used to influence consumer behaviour. The most prominent theory within this field is nudge theory (Cai, 2020), which aims to slightly alter choice architecture by applying nudges to achieve desired behaviours in consumers (Hall, 2013). Choice architecture refers to the social or physical environment in which choices are made. Rather than changing value systems or increasing information provision, nudging focuses on enabling behaviours and private decisions that are beneficial for individuals and society (Mont et al., 2014). Thaler and Sunstein (2008) define nudging as: "... any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates."

This definition suggests that nudges should avoid rigid regulations or enforcement mechanisms. Instead, they should focus on education, persuasion, and environmental stewardship. Nudges should therefore be non-intrusive and non-coercive, allowing visitors to opt out without inconvenience. Hausman and Welch (2010, p. 126) further proposed broadening the definition of nudges to include various types of incentives. They define a nudge as "ways of influencing choice without limiting the choice set or making alternatives appreciably more costly in terms of time, trouble, social sanctions, and so forth." Another definition suggests that nudging attempts to influence judgment, choice or behaviour by working on "cognitive boundaries, biases, routines, and habits in decision-making" (Hansen, 2016, p.158). Providing information, however, is a contested example of nudging. Some regard it as a nudge only when it is about simplifying information (Ölander & Thøgersen, 2014).

To this end, nudges may be designed to subtly encourage desired behaviours, such as walking or biking, without penalising alternatives such as driving motorised vehicles. By way of example, creating scenic walking paths or providing incentives for carpooling can promote sustainable mobility choices without imposing restrictions upon visitors. In adhering to principles such as predictability, choice preservation, ease of avoidance, and non-mandatoriness, nudges can effectively promote sustainable mobility and responsible behaviour in nature areas while simultaneously respecting individual autonomy and enhancing the overall visitor experience. While communication involves the direct transmission of information or messages to influence attitudes, beliefs or behaviours, nudging focuses on subtly guiding behaviour through changes in the choice architecture

without the need for explicit communication. For the purpose of this research, it is suggested that nudges should act as prompts to create awareness about and subtly lead towards sustainable mobility options among the visitors of nature areas.

According to Hansen and Jespersen (2013), nudges can be broadly categorised into type 1 and type 2, both targeting automatic modes of thinking:

- *Type 1 nudges* are designed to influence automatic behaviours by modifying the environmental context in which decisions are made. These nudges work by subtly adjusting the surroundings to steer individuals towards certain behaviours without requiring active decision-making or conscious awareness. They exploit psychological biases and heuristics, leading to immediate and often subconscious behavioural changes. An example of a type 1 nudge in a nature area context is the strategic placement of pathways and signage to guide visitors' movements and protect sensitive ecosystems. For instance, creating well-marked trails and placing signs that subtly encourage people to stay on the paths can reduce environmental damage and preserve wildlife habitats. This nudge operates by adjusting the physical environment to influence visitors' behaviour automatically, ensuring they follow designated routes without needing to consciously decide to avoid off-trail areas.
- *Type 2 nudges* influence behaviour by engaging both the peripheral and central information processing routes, prompting individuals to make active choices based on automated triggers. These nudges leverage psychological biases to initiate a response but also require some level of conscious decision-making, often invoking emotional reactions and facilitating long-term behavioural changes. An example of a type 2 nudge in a nature area context is providing visitors with information about the environmental impact of their actions, combined with prompts to make more sustainable choices. For instance, a nature area might install interactive signs at the entrance or along trails that show the negative effects of littering on local wildlife. These signs could include emotional appeals and vivid imagery to evoke concern for the environment (a peripheral cue). Additionally, the signs might offer specific suggestions for visitors to follow, such as using designated waste bins or taking their trash home with them. By highlighting the immediate benefits of these actions for the park's ecosystem and encouraging a conscious decision to act responsibly, this nudge engages visitors in a reflective process, prompting them to actively choose to protect the natural area. This combination of emotional engagement and actionable advice exemplifies a type 2 nudge, aiming to foster long-term environmental stewardship.

Green nudges

Nudges that aim to induce pro-environmental behaviour are broadly termed green nudges (Schubert, 2017). In consciously seeking to minimise the negative impact of one's actions on the natural and built world, green nudges can be used to conserve energy,

promote sustainable product purchase (Taube & Vetter, 2019), or to decrease emissions from transportation (Lieberoth et al., 2018). Environmental conservation ranks as the second most explored field in nudging literature, indicating sustained interest despite limited empirical evidence (Hummel & Maedche, 2019).

Green nudges offer subtle yet effective ways to encourage individuals to make environmentally conscious choices (Mont et al., 2014). However, one of the key challenges in environmental initiatives is the invisibility of their impact, which can hinder engagement with such interventions (Münscher et al., 2016; Thaler & Sunstein, 2008). Nevertheless, studies have demonstrated the effectiveness of nudges in facilitating sustainable behaviours. For instance, feedback nudges that display potential energy savings as monetary gains have proven highly engaging, leading to their adoption by energy providers (Thaler & Sunstein, 2008). Additionally, combining feedback nudges with social comparison techniques has further enhanced their effectiveness in promoting energy conservation among consumers (Chang et al., 2015). Some common types of nudges used in environmental contexts are social norms, feedback and priming.

- Social norms leverage the natural human desire to conform to societal expectations (Hummel & Maedche, 2019) and are typically classified as Type 2 non-transparent nudges (Hansen & Jespersen, 2013). Among the various psychological phenomena targeted within this category, social comparison is particularly common. Known as the 'herd instinct', this tendency drives individuals to align their experiences, beliefs, and actions with those of others, even to the extent of overriding their own beliefs if they differ from the majority. This heuristic forms the basis for one of the most effective and widely used nudging strategies such as social norms (Hummel & Maedche, 2019). Social norms have been extensively utilised in governmental campaigns, such as informing residents that the majority have already filed their tax returns to nudge procrastinators. Research on nudging in nonprofits, particularly for environmental causes, indicates that social norms are one of the most frequently employed nudging tactics in this context. Bonini, Hadjichristidis and Graffeo's (2018) study calls for clear communication of acceptable behaviour within a social group and suggests that combining descriptive norms with vivid details enhances their impact, serving as a valuable tool for policymakers to encourage environmentally friendly behaviours in nature areas. Some examples mentioned in the study are: "Most people are willing to give a small contribution to help reforestation"; "Nine out of ten clients which stayed in this hotel room reused their towel"; "Your electricity consumption exceeds the mean consumption of your neighbours by 10%".

- Feedback nudges, though less commonly encountered, are notably relevant in the environmental context (Chang, Huh, & Lee, 2016). Thaler and Sunstein (2008) argue that the effectiveness of feedback nudges stems from an individual's difficulty in

understanding the full impact of their actions due to the invisibility of those actions. Therefore, through providing clear explanations or representations of the impact of an individual's behaviour, feedback nudges can motivate people to participate more actively or empathise with the desired behaviour (Münscher et al., 2016). In environmental contexts, feedback nudges are commonly used to promote energy consumption reduction. This includes visualising the amount of energy consumed or converting lower energy consumption levels into monetary savings, which can incentivise individuals who might not be primarily concerned about the environment (Thaler & Sunstein, 2008). Feedback nudges offer a direct way to make the consequences of actions more tangible, as individuals often struggle to see, for example, the immediate effects of their energy consumption or waste production. By translating abstract actions into concrete terms, such as energy use into cost savings, these nudges can bridge the gap between behaviour and impact. A significant challenge in using feedback as a nudging technique is the assumption that individuals will be motivated by the feedback provided. While some may respond positively to seeing their energy savings, others may not find the information compelling enough to change their behaviour, especially if they are not financially motivated or do not prioritize environmental concerns. Additionally, the effectiveness of feedback nudges can diminish over time if individuals become desensitised to the information, suggesting that these interventions might need to be regularly updated or supplemented with other strategies to maintain their impact.

- Classified as a Type 2 non-transparent nudge (Hansen & Jespersen, 2013), priming nudges are subtle interventions designed to influence people's behaviours and decisions by evoking specific emotions or thoughts without their conscious awareness. These nudges ‘prime’ individuals by preparing their minds for certain choices through indirect cues, often using media such as pictures, videos, or other sensory stimuli. Priming works by subtly activating particular mental associations, making certain responses more likely (Mirsch et al., 2017). Priming nudges are frequently used to instigate emotional reactions, sometimes being specifically referred to as "empathy-inducing" (Caraban et al., 2019). Mirsch et al. (2017) illustrate priming with the example of an airline using impactful images of holiday destinations. These images evoke feelings of euphoria associated with traveling, thus stimulating interest in certain destinations and potentially boosting flight sales. However, the effectiveness of priming nudges can vary significantly depending on individual differences and contextual factors. For instance, a picture of a serene natural landscape may evoke strong positive emotions in one person but have little to no effect on another. This variability can limit the predictability and reliability of priming as a nudge technique. While priming can be powerful in short-term decision-making, its impact on long-term behaviour change is less

certain (Bimonte et al., 2020). Emotions induced by priming might fade quickly, reducing the nudge's effectiveness over time. This suggests that priming should be used in conjunction with other strategies to ensure sustained behaviour change (Sunstein, 2014).

Examples of nudging in tourism and nudging within nature areas

Within the tourism context, nudges are being utilized across various domains, including destination management (Benner, 2020), hospitality establishments like hotels and restaurants (Cozzio et al., 2020), transportation systems (Metcalfe & Dolan, 2012), and online booking platforms (Kim et al., 2020). Research on nudges in tourism primarily centres on sustainability issues (Souza et al., 2023). They are particularly addressing concerns related to climate change and environmental preservation (Hall, 2013; Higham et al., 2013; Nelson et al., 2019; Tussyadiah & Miller, 2019), promoting healthier food choices within restaurant settings (Filimonau et al., 2017), reducing food waste (Dolnicar, Juvan, & Grün, 2020) or evaluating products and services in digital environments (Tan et al., 2018; Tassiello et al., 2018). Greene et al. (2024) found that out of five intervention mechanisms (changing beliefs, social norm-based, pleasure-focused, penalty-focused, and choice architecture) increasing pleasure and changing the choice architecture are the most effective at increasing pro-environmental behaviour. In contrast to Chen et al. (2023), Greene et al. (2023) found only small overall effects of social norms. The latter authors do acknowledge some contexts in which changing beliefs is successful at increasing pro-environmental behaviour. However, Hall (2013) and Higham et al. (2013) posit that nudging can be part of the solution of governing sustainable behaviour and mobility but cannot be seen without the system within which it is located, such as the growth paradigm (Higham et al., 2013) and socio-technical systems which can constrain or guide certain consumer choices (Hall, 2013).

In an urban context Chen et al. (2023) used colour to nudge tourists to consider walking as a means of transport and found that differently coloured sidewalks increased tourists' interest in walking. Furthermore, the authors found that descriptive social norms related to walking (e.g., saying that walking is popular among tourists) further increased this interest. Similarly, Bradford and McIntyre (2007) found that messages informing park visitors to stay on trails work better if they are placed in areas where 'social trails' (illegal trails made by visitors) are located. Moreover, attribution messages are found to be more effective than plea messages. The former involves a personal locus of causality (e.g., "you are trampling vulnerable nature by using this trail"), compared to plea messages, which only involve discouraging social trail use, using formulations such as "please don't use this trail" (Bradford & McIntyre, 2007).

Dolnicar (2020) explored the effect of changing defaults in travel decisions. Opting out, rather than opting in, or offering more sustainable products or services by default (e.g., recycled servettes or cleaning rooms once during a stay), while offering the option of another product or service at no additional cost, increased environmentally friendly

behaviour. Increasing pleasure is seen as different from nudging, but could be used complementary to it, e.g., by awarding a drinks voucher to hotel guests who do not opt out of non-daily room cleaning (Dolnicar, 2023). Likewise, Gössling et al. (2019) found effective nudging interventions in the context of linen use in hotels. Normative appeals show an overall positive effect on pro-environmental behaviour, though in the context of hotels, non-transparency about the distribution of savings leads to more limited effects (Shang et al., 2010). Only a small number of studies have developed nudges as interventions proven to reduce plate waste. Kallbekken et al. (2013) identified two effective measures: using table signs to encourage guests to return to the buffet as often as they want, reducing plate waste by about 20%, and reducing plate size by 3 cm, which also decreased waste by 20%. The table signs appealed to social norms and required cognitive processing, while smaller plates were an infrastructural change requiring no cognitive effort. Despite smaller plates, guests could return to the buffet as often as they liked, maintaining guest satisfaction.

Most other studies were conducted in staff or university cafeterias, where food is more of a necessity than a pleasure. For example, charging students a fee for leaving plate waste reduced waste by 54% in a university setting (Kuo & Shih, 2016), whereas educating students had no effect. However, interventions that work in canteens may not be effective in hotels or restaurants, where dining is a memorable and expensive experience. Financial incentives and portion reductions that work in canteens are not feasible in hotel buffets. Therefore, the tourism and hospitality sector requires different interventions. To this end, Dolnicar et al.'s (2020) study focused on families, who generate the most plate waste, and employed a game-based intervention to increase pleasure rather than sacrifice enjoyment for environmental benefits. This quasi-experimental field study contributes to knowledge by developing and proving the effectiveness of a new intervention aimed at reducing plate waste in the tourism industry. It uses a causal research design and actual behaviour as a dependent variable, establishing a practical foundation for reducing plate waste and its environmental impact. The study demonstrates that increasing pleasure through a stamp collection booklet can encourage environmentally friendly behaviour in a pleasure-focused context. It also provides empirical evidence that pro-environmental appeals alone are ineffective, highlighting the potential of social norms and low-cost awareness-raising interventions, such as flyers, in reducing plate waste.

Within nature areas, there are several illustrative cases worth mentioning in more detail. By way of example, Pihlajamaa, Heino and Kuisma (2019) proposed the mobile app to nudge the Nuuksio National Park visitors in Finland towards sustainable mobility behaviour. The main challenge was the significant increase in yearly visitors, particularly during peak seasons. However, the majority of visitors (84%) rely on private cars to reach the park. The limited road infrastructure and parking facilities have resulted in congestion and difficulties in finding available parking spaces. Public transportation is not a widely adopted option due to the area's narrow roads, and the lack of suitable alternatives has

contributed to the reliance on private vehicles. The challenge was to manage and redirect visitor traffic to alleviate congestion issues, encouraging more sustainable transportation methods such as shared rides, on-demand transit, shuttles, and rental bikes. To this end, the Parkkihaukka app was designed to nudge visitors toward sustainable travel choices in the national park by offering real-time information on parking lot occupancy, enabling users to avoid crowded areas and promoting a smoother flow of visitors. Additionally, the app provides real-time bus timetables, encouraging users to opt for public transportation as a convenient and eco-friendly alternative to private cars. Parkkihaukka also supplies details about various facilities and attractions within the national park, highlighting alternative destinations to encourage users to explore less crowded areas, thereby contributing to a more even distribution of visitors. The app's overarching goal is to present the key information at the decision-making moments of the visitors while aiming to reduce the environmental impact associated with private vehicle use.

Another example is a study by Nelson, Partelow and Schlüter (2019) who explored the effectiveness of nudging tourists to donate for conservation on Gili Trawangan island in Indonesia. The island has grown into a major tourist destination receiving heavy tourist traffic, up to 2000 new visitors per day. Despite its small size and rapid development, the island faces issues such as solid waste pollution, with an impending crisis due to the overcapacity landfill and lack of government plans for waste management. The marine park, lacking an entry fee for tourists, relies on a voluntary contribution from scuba divers only, creating a need for a broader, consensus-driven approach to address environmental issues and fund conservation efforts for the entire tourist base. The study therefore explored the effectiveness of various nudging mechanisms in encouraging voluntary contributions from tourists to support a local non-governmental organization focused on coastal management within a marine park. Those mechanisms included open-ended contributions, suggested donation amounts, and opt-in/opt-out donations at different default price levels. This field experiment investigated how the presentation of choices influences tourists' decisions regarding conservation donations in a coastal tourist destination. Notably, novel aspects were proposed such as opt-in and opt-out payment mechanisms, the collection of real donations, indiscriminate targeting of all tourists, and the bundling of conservation actions across both land and sea issues impacting the coastal area. The implementation of a well-executed, appropriately priced voluntary tourist eco-fee was expected to yield substantial financial benefits for Gili Trawangan's conservation efforts. The opt-out condition at 10,000IDR garnered the highest donation rates, suggesting an effective upper bound for the eco-fee. With approximately 1 million annual tourists, a 10,000IDR-20,000IDR opt-out donation could generate between $400,000USD and $550,000USD, complementing current diver contributions and adequately financing Gili Eco Trust programmes for waste management and marine issues. The default opt-out donation mechanism, extended to all coastal area users, has the potential to generate substantial revenue while maintaining affordability for widespread participation.

Furthermore, Stanford (2014) took a market segmentation approach to achieving behaviour change in reducing visitor car use in Lake District National Park in Cumbria, one of Britain's most cherished outdoor destinations. In Cumbria, 85% of visitors use a motorised vehicle (car, van, motorbike or motor-home) to arrive, and 80% of tourists use cars and other types of motorised vehicles to travel around the destination. The environmental burden associated with visitor transport, including pollution, congestion, and community impacts, prompted the exploration of strategies to mitigate these issues. Commissioned by Natural England, in collaboration with Friends of the Lake District and Cumbria Tourism, the study identified propositions that appeal to specific market segments, acknowledging the limitations of solely focusing on visitor transport while recognizing the broader environmental impacts. The study particularly focused on leisure travel, which constitutes a significant portion of total energy consumption. The study proposed persuasive marketing messages to influence sustainable behaviour in nature parks, revolving around promoting environmental responsibility and personal benefits. Messages emphasizing the importance of "protecting the Lakes" were found to be most compelling for respondents, suggesting that a proposition tied to landscape conservation and the feel-good factor resonated well. Additionally, addressing perceived behavioural control and alleviating fears about the difficulty of reducing car use emerged as a strong message. On the contrary, however, messages based on the influence exerted by others (peers, celebrities, or authority) were found to be less likely to appeal, indicating that the peripheral route of persuasion might be ineffectual for this audience. Cost considerations were acknowledged as having potential influence, especially at the point of sale. The study emphasizes the importance of tailoring messages to different market segments, and recognising the diversity of attitudes and responses among visitors.

Case study: World Championship in Nordic skiing, 2023, Slovenia

The Green Scheme of Slovenian Tourism (GSST) is a tool developed at the national level and a certification programme that carries out the following tasks under the Slovenia Green umbrella brand (STB, 2024):

- Brings together all efforts directed towards the sustainable development of tourism in Slovenia;
- Offers tools to destinations and service providers that enable them to evaluate and improve their sustainability endeavours;
- And promotes these green endeavours through the Slovenia Green brand.

As part of the green scheme of Slovenian tourism, concepts such as green destinations, green hotels, green attractions, etc., have been put forward, however, great efforts have been made to also include green events in this portfolio of Slovenian green offers.

The environmental impacts of major sporting events significantly influence their long-term costs and benefits (Getz & Page, 2016). Thus, in the context of events sustainable

principles must be integrated and planned according to quality management frameworks. Organizing such events requires sustainable practices and solutions that document environmental impacts, such as waste management, soft mobility usage, energy-saving technologies, and water consumption (Chalip & Fairley, 2019).

The FIS Nordic World Ski Championships Planica 2023, Slovenia's largest winter sports event, was held in Triglav National Park in Planica, an Alpine valley renowned for its ski jumping and cross-country skiing facilities. The Event's Organising Committee adopted a professional and responsible approach to the preparation of the event, highlighting the need for a more sustainable sports event organisation. In recognising the reciprocal relationship between events and the natural environment in which they are taking place, they aim to take measures needed to mitigate negative impacts and enhance positive ones, while establishing a lasting legacy within a destination. In their study at the Planica Fis Ski Jumping World Cup, Juvan and Lesjak (2024) measured the amounts of plate waste generated by different sport event spectators. The authors suggest that event organisers must put in place interventions, which will address attitudinal and contextual drivers of unsustainable practices. Such interventions must increase pro-environmental beliefs as well as lead to the re-design of existing practices and services.

To this end, the Planica 2023 Green Team leveraged the event's communication potential to promote sustainable development and encouraged everyone to make a 'green commitment' within the Green Planica 2023 project. Drawing from previous experiences and expert advice, they set and monitored objectives, while making adjustments as needed. A member of the Green Team, Dr. Miha Lesjak from the University of Primorska, explained:

> *"It was a great initiative to provide specific guidelines on sustainable behaviour, helping participants understand the importance of sustainability. For example, one activity involved making tea by pedalling a bike to boil water. We wanted them to understand that even though this requires a bit more time investment it is more responsible, and therefore sustainable."*

The Green Team developed an action plan that tackles five key areas, namely mobility, waste and environment, social responsibility and communication, food and drinks and legacy. For each of these areas, specific goals were defined, as well as the measures that need to be taken in order to achieve the set goals (Green Planica Action Plan, 2023). More specifically, in the mobility domain, commitments were made to reduce transportation within the destination and to reduce the mobility carbon footprint through a number of measures, as shown below:

Table 5. Green team action plan for Mobility

Reduction of transportation	6	We will prepare a sustainable mobility plan for the mobility needs of the event
	7	We will promote carpooling for car transportation to Planica
	8	60% of the scheduled meetings will be held online (reduction of participant transportation)
	9	As part of the entire event, we will reduce transportation by 10% compared to previous events
Mobility carbon footprint reduction	10	We will provide footpaths, cycling routes and cross-country ski tracks for arrival to Planica (green types of mobility)
	11	In collaboration with our transportation partners, we will provide additional train (Jesenice) and bus transportation to Planica and back
	12	We will promote 10k/h reduction of driving speed for car transportation
	13	We will provide free train transportation for all visitors with tickets and accreditations

Source: *Green Planica 2023 Action Plan.*

The increased number of cars in the destination leads to the harmful emissions of greenhouse gases, the problems with parking spaces, and the discontent of the local population are just some of the negative effects of a big event as the World Championships in Planica. The Green Team were therefore actively making efforts to engage with the visitors (spectators) by nudging them into more sustainable mobility options by communicating engaging messages both on the website and on-site:

> *"Embrace the ride by train or bus. Or make sure your car is full of fans when going to the competitions. Do you have an option to come by bike, on skis or on foot? Take that option! Your body and nature will be grateful."*

Communicating engaging messages as a form of green nudges, alternatives like public transportation, carpooling, biking, skiing, or walking were actively promoted. This approach was hoped to nudge visitors towards more environmentally friendly travel choices by emphasising personal and environmental benefits, making sustainable actions more attractive and socially normative. Promoting shared transport options like carpooling or using public transport generates a sense of community and shared responsibility, while highlighting the benefits ("Your body and nature will be grateful"), the messages might encourage positive behavioural change.

Dr. Lesjak further explained that there were different ways in which the visitors were nudged to adopt more sustainable behaviour:

"At the event, we had a push the green button and make the pledge initiative, a type of gamification with which we hoped to influence a slight change in people's mindset."

Figure 11. Push the green button nudge, Planica (Source: Personal archives)

By pushing the button, the visitors are taken to the website where they can download the 'roadmap' to their sustainable day which involves 'tasks' (ideas) across five identified domains in which they could make an impact. They could also calculate their carbon footprint. This real-time information is aimed at nudging visitors towards lower-impact travel behaviour without restricting their options. Providing immediate feedback on their carbon footprint helps them see the direct consequences of their choices, which can create social pressure to conform to more sustainable behaviours. This aligns with the earlier discussion on social norms influencing human behaviour, where people adjust their actions to fit in with what they perceive as acceptable or expected.

It is also worth mentioning that in seeking sustainable synergies the event collaborated with the ECO School project, preparing the challenge: "How to become an environmentally friendly fan", inviting students from primary and secondary Slovenian schools to present solutions for attending a sports event in a sustainable way. They focused on the topics of sustainable mobility, waste management, social responsibility and healthy lifestyle. The challenge winners were announced in Planica during the event "Through sustainable events to a carbon-neutral and resource-efficient society."

By establishing transparent and reliable metrics for assessing the ESG (Environmental, Social and Governance) impacts of sports events, Slovenia is setting new standards in the industry, promoting competitiveness, and ensuring that sport, as a global force, operates for the benefit not only of current but also future generations.

Figure 12. Green Planica 2023 Action Plan (Source: www.planica2023.si)

Case study: SLOW ADVENTURE LTD

In 2022, Slow Adventure Ltd (2024) was launched and now offers experiences in 6 destinations (Scotland, Iceland, Finland, Sweden, Italy and Spain). The human-powered journeys take place in remote, off-the-beaten-track regions. They enable a better way of adventuring by creating a circle of respect in adventure tourism that protects and regenerates fragile ecosystems. We are building a movement that helps restore the natural balance between local communities, visitors and nature to enrich the lives of all involved. Led by the original pioneers of the slow adventure movement (Varley & Semple, 2015; Farkic, Filep, & Taylor, 2020; Farkic, Taylor, & Bellshaw, 2023), Slow Adventure Ltd nudges visitors to give back to local conservation projects through the impact fund which benefits local communities and the natural environment where our adventures take place.

The core values of Slow Adventure Ltd are:

- Inviting visitors to journey by human-power, to slow down, spend more time, and connect meaningfully with nature and the people who live there;
- Creating a grassroots movement where local people build adventures for visitors and shape how visitors engage with the local area;
- Creating a fair and transparent way for visitors to donate to local conservation projects each time they book an adventure to support fragile ecosystems.

Sara Mair Bellshaw, co-founder and Managing Director of Slow Adventure and one of the pioneers of the slow adventure movement, is passionate about changing the travel landscape by creating the conditions for people to give back to local conservation and regeneration whilst also choosing a less impactful way of adventuring. Ms Bellshaw believes that, if they as a tiny company with limited resources, can do this, so can others. They would like to see every business and their customers taking genuine responsibility for their impact on the natural landscape:

> *"We're building a global movement of people who understand that it's no longer possible to adventure without giving back. Tourism and adventure travel needs to be created and shaped by local people who cherish and protect where they live. If we choose to adventure, we must do so responsibly. If we choose to go, then we ought to go for longer. If we choose to spend, then we ought to spend well with a responsible local. If we adventure in nature, we ought to do so mindfully and under our own steam. If we tread on landscape and experience culture, we ought to donate to regenerate the places we visit."*

The world is facing an unprecedented nature-climate crisis and while different mechanisms such as ESG standards are gradually being enforced on businesses, there is no obligation on the customer to take responsibility for their impact. Slow Adventure Ltd, however, chooses to nudge the customers to donate 5% of the price of their trip towards

a local impact project of their choice as part of the booking process, and according to customer feedback this is one of the main reasons for booking with Slow Adventure Ltd. Through our Impact Fund, customers donate directly to local conservation projects in the area they visit, making the impact and benefits for communities and the natural environment clear for all.

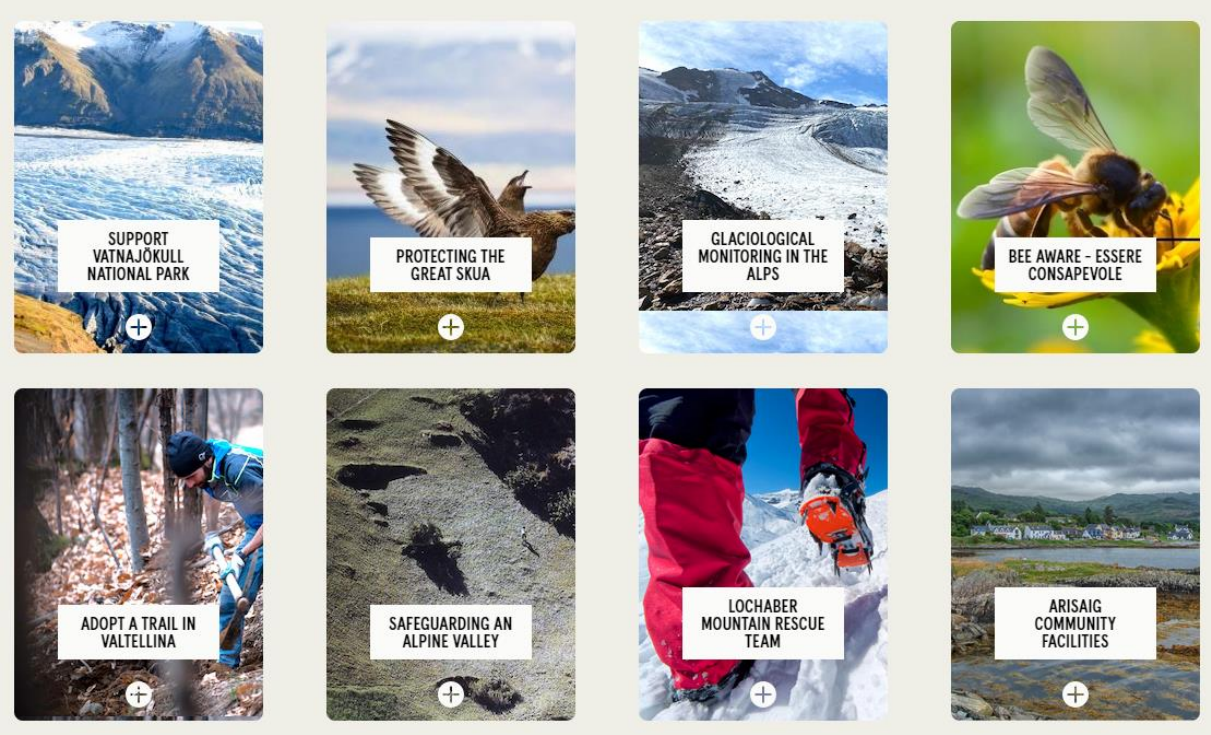

Figure 13. Examples of the impact fund options (Source: Impact | Slow Adventure (slow-adventure.com)

The adventure tourism, outdoor activities, and sports tourism sectors need to do far more to help close the global biodiversity financing gap. Slow Adventure Ltd is creating the conditions to do this on a local level worldwide so that the places where we live can continue to thrive. One way of committing to this ambition is by encouraging non-motorised movement through places. Ms. Bellshaw further explains:

> *"When journeying through a landscape by human power, people naturally slow down and create meaningful connections with a place. This increased connection with, and understanding of, nature leads to a desire to want to protect it more which is why our adventures don't include motorised vehicles. It's vital that we reduce our carbon footprint because climate change is one of the main drivers of biodiversity loss, and therefore we also make it easy for our customers to donate to impact projects that protect and restore the places that are local to the adventure."*

Conclusions and recommendations

Nature-based recreation has grown over the years, partially due to the COVID-19 pandemic. While nature areas have traditionally needed to fulfil a dual mandate – balancing visitation and protecting biodiversity and wildlife, establishing a delicate balance between environmental protection and accommodating visitor interests, the increased interest in nature-based recreation has provided additional challenges for sustainable management of these resources.

Various terms for nature areas can be found in the literature, such as natural areas, nature reserves, wilderness areas, and national parks. Protected areas are defined by the IUCN (2008) as spaces managed for long-term conservation and cultural values. These areas have various conservation, economic, and social objectives, and can be classified into six categories according to different levels of human activity and conservation focus. Additionally, governance types vary from government to local communities. The MONA project considers in its activities the protected areas with diverse management categories, united under the umbrella term "nature areas."

A large body of literature has outlined the challenges faced by nature-based tourism in terms of the impacts made on the natural environment and its immediate surroundings. Increased visitation to nature areas in combination with pre-dominant use of car transport for recreational needs, leads to transportation challenges, contributing to atmospheric emissions and road congestion. Steiner & Bristow (2000) highlight this difficult contradiction parks face due to car-based travel increase, as the environment intended for public enjoyment and biodiversity preservation is eroded by traffic volumes. Local motorized traffic within parks adds noise pollution, wildlife disruption, and chemical contamination. Environmental impacts include vegetation damage, soil compaction, and wildlife disturbance, while social impacts involve crowding, reduced visitor satisfaction and lower quality of life of local population living within or in proximity of nature areas. Fortin and Gagnon (1999) assessed the social impacts of national parks on local communities, identifying four key areas: resource management, economy, living conditions, and local involvement. Conservation zones often restrict local land use, affecting recreational activities and economic opportunities. Economically, parks can boost infrastructure and tourism, but may also lead to the increase of the resident living costs. Increased tourism can strain local resources, causing road congestion and parking issues. However, it is also important to recognize the important values visitation to nature areas has in terms of, among others, educational , sport and recreation opportunities, and health and wellbeing benefits. Furthermore, while tourism undoubtedly has an undesired ecological impact, it can also provide a key incentive for protective measures of landscapes and ecosystems.

The extant research has shown there are strong interrelations between tourism and transport. According to Feng (2023), the high-quality coupling of tourism and transportation systems can greatly promote sustainable development and further enhance their positive effects for the people and the planet. Guhneman et al. (2021) note that the accessibility of destinations and local mobility services can significantly increase a tourist destination's attractiveness, promoting competition and influencing transportation choices for arrival, departure, and on-site mobility. It is important to reveal the spatial coupling relationship between regional tourism traffic accessibility and the tourism economy at the local level. That is specifically relevant for the nature areas, that are often located away from urban areas, which are, as such, characterised by lower public transport networks and, in some cases, accessibility to more sustainable travel options.

To develop efficient approaches to reducing car-dependent access to nature areas, it is important to firstly understand the intrinsic motivations of the visitors guiding their decision to visit nature areas and their behaviour within them. The travel motivations vary based on whether nature is viewed as a primary attraction or as a backdrop for diverse activities. Motivations to visit might include wildlife protection or observation, sports and adventure, and social or hedonistic experiences. This information helps to guide spreading and routing practices, that are being developed in response to overtourism issues. Key concepts like carrying capacity, encompassing ecological and social dimensions, underscore the complexity of managing visitor impacts effectively. Routing strategies play a crucial role in mitigating overtourism by guiding visitors along designated paths to disperse crowds and reduce pressure on sensitive areas. These strategies require environmental impact assessments and consideration of visitor preferences, supported by both hardware – such as trails, parking spaces, visitor centres, benches, signage – and software – information provision and new technologies like mobile apps for personalized route planning.

Second, it is necessary to have a clear understanding of the leisure mobility behaviour, determinants, as those help in achieving modal shift. Mobility behaviour to and within nature areas is determined by two main factors: objective/hard/physical factors (e.g., quality of public transport systems) and objective/soft/social factors (e.g., attitudes and perceptions), which roughly relate to supply and demand factors, respectively. Objective factors shape available options, while subjective factors include users' preferences and habits. The built environment's density, diversity, and design significantly impact mobility behaviour: urban areas often provide a large variety of sustainable transportation options compared to car-dependent rural areas. Socio-demographic factors such as age, income, family life cycle, and car ownership also influence travel mode choices. Tourism and leisure mobility have also unique characteristics, including varying peak hours, seasonality impacts, and greater weather dependency.

A modal shift in tourism therefore suggests transitioning from private car use to more sustainable modes like public transport, cycling, and walking. Achieving this shift in nature areas requires balancing visitor motivations with other mobility behaviour determinants.

Some of the key requirements to achieve the effective modal shift require meeting of tourists' needs, ensuring the availability of sustainable transport for the entire journey, and providing accessible information and attractive pricing. Studies highlight that car users value flexibility, especially for multi-destination trips. Rail tourism, connecting urban centres with rural areas, shows potential, though it faces barriers like high costs and infrequent and unreliable services, especially on weekends. Enhancing public transport and making railway stations and bus stops functional and attractive can greatly facilitate the modal shift.

Finally, deliverable 1.1.1 zoomed into the interventions for sustainable mobility in nature areas, such as "nudges" that subtly guide individuals toward more desirable mobility choices without restricting their freedom. The main goal is to use consumer insights to influence their behaviour effectively, with nudge theory being the most prominent framework that underpins MONA's project activities and contributes to the achievement of its objectives There are diverse forms of nudges, all of them working towards altering the choice architecture, enabling beneficial behaviours without mandating them. For example, green nudges are designed to promote environmentally friendly behaviours, such as conserving energy, reducing emissions, and choosing sustainable products. One challenge with green nudges is the invisibility of their immediate impact, which can hinder engagement with certain initiatives.

Overall, a combination of "push and pull" measures is necessary to achieve tangible decrease in the usage of cars to access the nature areas. As Holding et al. (1998) suggest, "pull" measures alone are ineffective by themselves and "push" measures might be essential to achieve the real modal shift.

The literature review and conducted expert interviews has resulted in the following recommendations:

1. Research Needs: Further research is necessary to understand leisure behaviour and integrate transportation and tourism systems for sustainable development. Addressing literature gaps will enhance strategies for promoting sustainable tourism and mobility.
2. Push Measures: Effective results require a combination of push and pull (such as nudging) measures to mitigate environmental impacts and improve visitor experiences.
3. Routing Measures: Routing should take a regional approach, cooperating with nearby relevant attractions (both natural and cultural) and divert less-intrinsically motivated visitors to less sensitive sites.
4. Public Transport Improvements: Enhancing public transport quality is essential for encouraging modal shifts. Focus on reliable and convenient transport options,

particularly to and from railway stations, can significantly influence travel behaviour.

5. Rail Transport Enhancements: For short-distance trips, improving transport quality to and from railway stations, integrating timetables of different public transport options and providing seamless connections and high-quality services will promote a shift from private car use to more sustainable travel modes.

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