

Review of environmental impacts of outdoor events with a focus on orienteering

Tami Lanzendorf, Henk Högemann, Lusine Margaryan



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MISTRA Sport & Outdoors, 2023

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Cover Photo: Henk Högemann

ISBN: 978-91-89786-23-3

Preface

This report is written by two Master students in Tourism Studies at Mid Sweden University – Tami Lanzendorf and Henk Högemann, under the supervision of the MISTRA-researcher Lusine Margaryan. Tami and Henk worked on this report during the spring semester of 2023 as part of their internship at the ETOUR Research Centre. During their internship they joined the research program MISTRA Sport and Outdoors via the working group focusing on Sustainable Events. The authors thank Joacim Ingelsson, Eje Andersson and Axel Eriksson for their valuable inputs.

This report provides a general overview of environmental impacts of outdoor events, subsequently highlighting the phenomenon of orienteering, which is rarely in focus in scientific literature and projects. Orienteering is an interesting sport to study in a MISTRA-context, not least based on the direct connections to both sport and outdoors.

I would like to take the opportunity to thank the authors of this publication. I hope this report will bring new insights into sustainable event development.

/Robert Pettersson, theme leader of Sustainable Events

Östersund, August 2023

Executive summary

The growing interest in the environmental impacts of outdoor events and festivals has sparked the need for systematic research, as limited information currently exists on the subject compared to economic and socio-cultural impacts. The primary objective of this popular science report is to provide an overview of existing research on environmental impacts of outdoor events specifically focusing on orienteering as a showcase example.

Orienteering, a widely popular outdoor sport, particularly in Scandinavia, has witnessed a surge in popularity. Given the sport's heavy reliance on natural resources, it is imperative to ascertain the extent of its negative impacts on the environment and identify factors that event organizers and participants should consider to contribute to the environmental sustainability of orienteering events.

This report underscores the limited understanding of the relationship between outdoor events and environmental sustainability, with transportation and travel emerging as primary contributors to adverse environmental consequences. It recognizes the need to prioritize sustainable transportation alternatives, such as public transport, and recommends situating event venues in proximity to these transportation options. Furthermore, the report proposes the implementation incentives to encourage sustainable travel behavior among event participants and tourists. Among direct impacts, soil erosion emerges as an issue in outdoor events, while orienteering events may also disrupt wildlife habitats and vegetation. Measures such as trail design and zoning considerations can help mitigate these impacts.

Responsible resource management, waste reduction, utilization of sustainable energy sources and water conservation practices are also highlighted as critical components for achieving environmental sustainability in orienteering events. The report emphasizes the availability of various methods and tools to measure and mitigate environmental impacts. However, it acknowledges the absence of a consensus on uniform sustainability assessment methods, indicating the need for further research in this area. The O-Ringen orienteering event serves as an example of a large-scale outdoor sport event with significant sustainability efforts, but further considerations are still needed to reduce the environmental footprint of orienteering events.

By promoting sustainable travel, venue selection, waste management, energy and water conservation, orienteering events can make significant progress towards achieving sustainability goals and minimizing their environmental impact. This commitment to sustainability contributes to the long-term viability of the sport while safeguarding the natural environment. Further research in various areas mentioned and the implementation of the recommendations outlined are crucial to propel sustainability efforts in outdoor events, particularly in the context of orienteering.

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1. INTRODUCTION

This report aims to provide a comprehensive overview of the environmental impacts associated with outdoor events, with a special focus on orienteering events. The report sheds light on the potential environmental consequences that may arise from such events, including but not limited to greenhouse gas emissions, land and water pollution, soil erosion, vegetation damage, and wildlife disturbance.

Methodologically, this report is based on the analysis of literature available through scientific databases and public domains, including both primarily academic but also grey literature. Focus is made on the sources directly addressing environmental impacts of outdoor events. It has to be emphasized, that scientific literature focusing on environmental impacts of events in general, and orienteering and orienteering events in particular is quite scarce. This lack of research has been widely recognized before (e.g. Eriksson et al., 2023; Mykletun, 2009; Margaryan & Fredman, 2021, 2021a). Therefore, certain generalizations and extrapolations were made based on the knowledge available from other comparable outdoor events, such as trail running and mountain biking competitions, as well as a more developed field of nature-based tourism. However, this is not always feasible since orienteering has its own unique specifics, as its impacts are dispersed in space and limited in time.

The report starts with a broader overview of events and sustainability, emphasizing the importance of events for tourism and regional development. It then moves to conceptualizing sustainable events, particularly outdoor events, which are the focus of the study. The next section provides an overview of the key environmental impacts of outdoor events, including both direct and indirect impacts. Indirect impacts are related to transportation and its challenges, while direct impacts include trampling, soil erosion, and disturbance of wildlife. Resource management is also investigated, particularly the use of materials, waste, and waste management, such as the use of energy and water. Additionally, best practices and tools of environmental impact management for outdoor events are lined out. This section provides practical recommendations for event organizers to minimize the environmental impacts of their events. The report then looks specifically at orienteering events, their prerequisites and environmental impacts. It therefore points out the potential environmental impacts that could occur during outdoor events such as orienteering. Finally, the report concludes by offering recommendations for more environmentally sustainable outdoor events.

Through the provision of state-of-the-art knowledge and recommendations, this report therefore aims to draw attention of both researchers and practitioners to the environmental impacts of outdoor events. This report highlights environmental impacts of outdoor events and especially orienteering events as a largely underresearched area, calling for further research attention from the scientific community (even though a lot of information could also be found from unpublished materials, and grey literature, such as reports of Swedish Orienteering Federation www.orientering.se and International Orienteering Federation orienteering.sport). Further, this report aims to contribute to the mitigation of environmental impacts by inviting event practitioners to foster a more sustainable approach to orienteering event

planning and management. By addressing the existing research gap concerning the environmental impacts of outdoor events, particularly in the context of orienteering, this report aims to support informed decision-making and promotes sustainable practices among event organizers, participants, and relevant stakeholders in the vibrant field of sport and outdoor events.

1.1 Events-tourism-sustainability nexus

Tourism and events are interrelated in a complex way, as they all have impacts of various magnitude on the environment, social and cultural systems and the economy. As a growing sector, tourism has become a significant contributor to the global economy and has the potential to promote economic growth and development in many regions. However, it can also lead to a range of negative impacts, such as environmental degradation and cultural erosion (Mikayilov et al., 2019; Wolf et al., 2019).

Sustainability, a societal goal that has been dominating international human development agenda for the last three decades, seeks to balance economic, environmental, and social considerations. It provides a framework for evaluating the impacts of tourism, events, and orienteering and seeks to minimize negative impacts while maximizing positive outcomes. Very broadly, sustainable tourism and events refer to relevant activities that are conducted in a manner that is not detrimental to the environment, supports local communities, and benefits the economy in the long term (Parker, 2005; McCullough et al., 2018; Ruhanen et al., 2019).

Events can be an important aspect of tourism (giving rise to 'event tourism' sector) and can have significant economic, social, and cultural impacts on the host communities. However, they also have significant environmental impacts, particularly outdoor events. As the popularity of outdoor events continues to grow, it is important to understand the environmental consequences of outdoor events and to implement sustainable practices. Addressing environmental sustainability is therefore a crucial aspect within event tourism planning and management (Ruhanen et al., 2019). This report focuses on orienteering – an outdoor sport, as a context to examine the environmental impacts of outdoor events. Orienteering is a sport that involves navigating through natural landscapes on foot, skis or by mountain bike, and has become increasingly popular in recent years (Huddart, 2019). Orienteering, while not relying on heavy infrastructure, can still cause significant environmental impacts.

Environmental quality overall is a crucial factor in sporting excellence, as it plays a critical role in the health and well-being of athletes. The ability to train and compete in clean air and water, and to consume healthy food, is essential to ensure optimal performance. This sentiment is echoed in Brownlie et al.'s (2020) research, which highlights the interrelationship between environmental quality and sports. Furthermore, the impact of environmental quality extends beyond just the athletes themselves. Fans and spectators also rely on clean air and water, scenic landscapes as well as other environmental factors, to enhance their experience as well as travelling motivation (Margaryan & Fossgard, 2021; Margaryan & Eriksson, 2023). Maintenance

of a healthy environment, therefore, is not only essential for athletes but for all those involved in the sporting community and beyond (Foroughi et al., 2014).

The issues of sustainability and environmental impacts have started to receive importance in event studies literature relatively recently, i.e. primarily within the last decade. Getz (2007) for example stated that conducting Environmental Impact Assessments (EIAs) before and after events should be the norm, however only large events are subject to this norm. Similarly, Gibson and Connell (2012) state that green initiatives at special events remain largely ad hoc without holistic planning and management. Mallen and Adams (2014) noted that environmental sustainability is certainly in its embryonic stage when it comes to event management, and work has just begun to move initiatives forward on the managerial agenda. Goldblatt's (2011) work on greener events was one of the first books focusing on this. Additionally, Page & Connell (2014) state that even though the environmental dimension of events is coming under increasing academic scrutiny, much of this remains tourism-oriented rather than focused on the plethora of events, local and national, that do not involve overnight stays by attendees. Overall, environmental sustainability of events is gaining more attention, but comprehensive research is still scarce (Trail & McCullough, 2018; 2021; Cavallin Toscani et al., 2022). Overall, despite growing concerns regarding environmental sustainability of events (e.g. Mallen & Adams, 2014; Yuan 2013; Hanrahan & Maguire 2015), an adequate sustainability effort from the event sector is yet to be seen (Holmes & Mair 2020; Mascarenhas et al. 2021).

Outdoor events like orienteering must therefore pay extra attention to sustainable management to prevent and mitigate potential environmental damage, especially on the physical environment. As of now, there has been limited research on environmental impacts of events, and most of it prioritized only very narrow range of impacts, e.g. CO2 emissions or littering. Overall, the importance of environmental quality in sports cannot be understated. It is therefore crucial to recognize the interdependence between sporting excellence and a healthy environment, and to prioritize sustainable practices that preserve environmental quality for present and future generations.

2. EVENTS AND SUSTAINABILITY

In recent years, sustainability and Sustainable Development Goals (SDGs) are gaining more visibility in event planning and management. The triple-bottom-line approach, which emphasizes the equal treatment of economic, environmental, and socio-cultural dimensions of sustainability, has gained widespread acceptance in the field (Getz, 2017). According to this approach, none of the three dimensions should be prioritized over the others. Instead, they should be given equal weight in the development of sustainable events.

While the triple-bottom-line approach has become the consensus in event research, there are criticisms of the assumption that all three pillars are treated as equally important (Vallström, 2014). The economic dimension often holds the highest weight, with environmental and socio-cultural concerns taking a secondary role. This creates a common challenge of balancing economic and social sustainability against environmental action (Vallström, 2014). In addition, a strong economic position that prioritizes growth may come at the expense of ethical and environmental considerations (Hall, 2019). To address this challenge, it is important to consider the many sustainability aspects of events, from their ecological footprint to their economic viability (Getz & Page, 2020). While all aspects are important, not all can be measured or prevented. Instead, events must strive for sets of goals in a continuous process. However, it should be noted that especially in the context of outdoor events, nature is often the very basis for the activity and the consideration of environmental sustainability aspects should therefore have a high priority. Certifications and measures, especially those related to environmental impact, can be accessible tools in this process, even though their efficiency is debatable (Hall & Page, 2012; Getz & Page, 2015; Kaplanidou & Gibson, 2010). In short, the triple-bottom-line approach and the SDGs remain the most popular approach for conceptualizing sustainable events. While criticism exists regarding the equal validity of all three pillars, it is important to strive for balance and involve the community in the planning and management process. By doing so, events can contribute to a more sustainable future for all.

2.1 Understanding events

An event, also referred to as a “special event” or “planned event” is “a tangible phenomenon bounded by space and time” (Patterson & Getz, 2013, p. 229) and has an intent to create an experience for individuals or collectively (Getz & Page, 2020). Events have different meanings and significance of an event is determined by numerous factors such as social, economic, and cultural (Getz & Page, 2020). Moreover, each culture has a unique way of perceiving and experiencing an event. Events have various social, cultural, and economic functions and characteristics (Getz, 2012). Events can generate economic benefits such as employment opportunities, destination development, and revenue generation. They can also promote social cohesion and cultural exchange among individuals and communities.

Events can be classified according to their size and frequency (Getz, 2008; Taks, 2013; Page & Connell, 2020). Small and medium-sized events, also known as non-mega events, are significant in creating an image for the destination. Additionally, small events foster and tighten the community and stakeholders, but their economic effects are usually limited (O'Brian & Chalip, 2007; Higham, 1999). On the other hand, mega-events provide a major boost in marketing and a platform for showcasing a destination (Deery & Jago, 2010).

Sporting events vary greatly, ranging from grand spectacles like the Olympic games to small-scale community events. According to Higham (1999), a sport event can be defined as a planned event that involves physical activity, has a competitive element, and has an audience. Gibson (2005) and Duglio and Beltramo (2017) suggest that sports events have at least two spheres, active and passive participation. Active participants are those who take part in the event, such as athletes, while passive participants are spectators, volunteers, and media personnel. Active sport events can be subdivided into professionals or amateurs, multi- or single-sport, competition, or leisure, among others. The experience of an event is what makes it memorable, and the degree of interaction with others during the event plays a significant role in creating this experience (Getz & Page, 2020).

In short, events are bounded by space and time and have an intent to create an experience for individuals or collectively. The meaning of an event varies across cultures, and it is important to consider cultural diversity when planning an event. Events have different functions and characteristics, and sport events can be categorized into active and passive participation. Finally, events can be classified based on their size and frequency, and each category has unique characteristics that affect their economic, social, and cultural impacts.

2.2 Importance of events for regional development

The importance of events for tourism and regional development has been widely recognized. Events create experiences for individuals or collectively within a specific space and time (Patterson & Getz, 2013). Weed (2012) developed five broad approaches to the question of what objective an event is trying to fulfil, including the development of activities for participation for common interest, social community development, nature protection, positive economic impact, and promotion of the area that links with the exterior such as media coverage or trade communities or another form of network.

Events are usually integral to tourism market planning. Hosting sporting events has become a key strategy for destinations to gain recognition (Kotze, 2006) and is often included in their event portfolios for annual tourism planning (Ziakas & Costa, 2011). Using events to mitigate seasonality and diversify tourist flows is a common objective, as it can contribute to the local visitor economy and enhances the overall viability of the destination (Getz & Page, 2015). Typically, rural events such as sports, music festivals, and smaller events are considered important for enhancing social sustainability within

local communities (Coaffee & Shaw, 2005; Gibson & Davidson, 2004; Duglio & Beltramo, 2017).

Events are suggested to serve as a platform for community socialization, where friends and families can gather and individuals can meet like-minded individuals and engage with outsiders, fostering a sense of belonging in a wider social environment (Nordvall et al., 2014). Events can further instill pride in the community and provide economic advantages (Deery & Jago, 2010). However, the short time span and tight development schedules present a challenge in initiating a meaningful dialogue with the public sphere to identify issues related to socio-ecological sustainability (Dredge & Whitford, 2011). O'Brien and Chalip (2007) argue that involving the community in the planning and management process at an early stage can help in the aim of addressing of all three pillars of sustainability. By putting locals at the forefront, events can focus not only on economic impact, but also on social and environmental impacts.

In conclusion, events have become an integral part of tourism planning and can play a vital role in regional development. The benefits of events go beyond economic impact and provide social, cultural, and environmental benefits to the local community. However, there are challenges in achieving a balance between economic growth and sustainable development. Event organizers need to engage in meaningful dialogue with local communities and stakeholders to ensure that events are socially and environmentally sustainable and contribute to the overall well-being of the destination.

3. ENVIRONMENTAL IMPACTS OF OUTDOOR EVENTS

There is growing interest among policymakers, event organizers, sponsors, and researchers to understand the environmental impacts of events (Collins & Cooper, 2017; Burton et al., 2021; Gibson & Wong, 2011). While tourism and events research have come far within in understanding economic impacts (Agha & Taks, 2015; Case, 2012; Duglio & Beltramo, 2017) as well socio-cultural and community-based impact (Wallstam et al., 2020; O'Brian & Chalip, 2007) of events, there is still relatively little information available on the environmental impacts. This could be due to the fact that generalizability is often very limited, and it is challenging to derive objective standards to evaluate and improve sustainability efforts in the event industry (Pereira et al., 2017). In recent years, however, the environmental aspect has been emphasized, as the increasing popularity of events as a tourism product puts a growing pressure on natural resources. On a macro-scale, climate change is a fundamental challenge, making the reduction of carbon emissions one of the priority goals (Heberlein, 2012). Aside from major macro-level impacts, micro-level impacts are unavoidable and occur due to concentrated use of natural resources (Cole, 2004).

Literature review of research within event studies suggests that environmental impacts of events are often mentioned *en passant*, as a general category. Terms like 'environmental issues', 'environmental concerns', 'environmental factors', 'environmental considerations', 'environmental degradation' etc., are often left without further in-depth unpacking. Exception from this generalization is literature dedicated to mega-events. It is not surprising that the sheer scale of these events and the global attention towards them has forced managers to pay more serious attention to environmental issues early on (Bravo et al., 2018; Di Vita & Morandi, 2017; Hayes & Karamichas, 2014; Lienhart & Preuss, 2014; Salazar et al., 2016).

The event literature that explicitly deals with the environmental impacts and concerns in-depth can be split into two groups: a) discrete/simplistic approach - those identifying several areas of environmental concern, i.e. direct impacts; and b) holistic/complex approach - those trying to understand how events transforms ecosystems and general environment around them, looking at multiple environmental dimensions underlying their interconnectivity. Of these, the discrete/simplistic approach is much more common.

Two most frequently mentioned key areas of environmental concern with event studies are transportation-related impacts (primarily green house gas (GHG) emissions) and waste management. Other mentioned impacts, albeit much less common, can be largely grouped as direct damage to the environment (land degradation and erosion, trampling, removal and damage to wild flora and fauna species, damage to natural heritage sites and their aesthetic properties, resource depletion); and indirect damage (nuisance, disturbance, noise, light, vibration). Growing concerns relate to the growing popularity of events located in remote and ecologically sensitive areas (e.g. islands, coastlines, areas with high biodiversity, habitats of endangered species, etc.).

Finally, events are more and more expected to not only avoid damaging the environment but also actively contribute to its improvement the conditions of the event location. This, primarily, relates to raising awareness about sustainability and stimulate adoption of environmentally friendly behavior (Gibson & Connell, 2014). It can also include such practices as achieving carbon-positivity (e.g. generating energy from renewable sources and feeding it to the grid, or through organizing or purchasing carbon offsets) or improvement of environmental quality on and around the event site (organizing cleanups, revitalization of unattractive/damaged environments, tree-planting etc.).

This report provides an overview of the broad spectrum of environmental impacts, ranging from operations and maintenance infrastructure (e.g., waste and resource infrastructure), transportation (e.g., traffic-related air pollution), energy consumption, to other negative impacts such as direct pressure on natural resources (e.g., land, flora and fauna, water pollution). For this purpose, the environmental impacts were divided into three main groups. First, transportation, responsible for significant environmental impacts at events, is discussed. Subsequently, literature on direct environmental impacts, which predominantly occur at sport and outdoor events, is presented. These are divided into three main categories: Impact on vegetation, impact on soil and disturbance of wildlife. Lastly, the environmental impacts related to use of resources such as water and energy are analyzed.

3.1 Transportation

The tourism and hospitality industry is one of the biggest contributors to climate change and was solely responsible for around 8.1% of all CO₂ emissions worldwide in 2013 (Lenzen et al., 2018). Transport-related CO₂ emissions account further up to 75% of the total direct emissions from the tourism sector, of which 40% can be attributed to air transportation and 32% to car traffic (UNWTO & UNEP, 2008). Considering greenhouse gas emissions alone, it becomes clear that transportation has by far the largest environmental impact within the tourism industry. In addition to air pollution from fossil fuel combustion, there are other environmental impacts. These are high energy consumption (vehicle manufacture, operation, and maintenance), soil and water contamination, noise pollution, land consumption and ecological degradation of natural habitat and wildlife (Rodrigue, 2020). While many of those environmental impacts apply to most modes of transportation, automobiles and air travel are the main contributors (UNWTO & ITF, 2019).

With the growing urgency of climate change growing attention within event research has been turned to the issue of GHG emissions. In this regard ensuring sustainable transportation options has been identified as an important priority for event managers. Gibson and Connell (2014) for example state that getting to and from a festival represents the single largest carbon emitting component of any music event. In fact travel emissions can outweigh a festival's internal emissions (lighting, freight, generators, etc.) by more than 10:1 ratio (Gibson & Connell, 2014). Already in 2007 Getz

stated that green events have to encompass more than on-site considerations, they have to look at the entire travel and hosting process, which has been lacking. It can be argued that achieving carbon-neutrality is currently featured as a priority in event sustainability policies (e.g. Gibson & Connell, 2014; Goldblatt, 2013; Hayes, G., & Karamichas, 2011; Mair, 2018).

There is a growing recognition that events are an increasingly important part of the tourism sector and have been proven to influence and amplify the effects of climate change. Since a disproportionate share of event-related emissions is due to transportation and travel, it represents the biggest sustainability related challenge for event organizers (Pereira et al., 2017). Furthermore, considering that event attendees are becoming increasingly international and therefore rely on long-distance transportation, the urgency of more sustainable transportation solutions becomes even more apparent (Burton et al., 2021). Existing literature addressing the environmental impacts of events related to transport focuses primarily on measurable CO₂ emissions (Ballarano et al., 2022) whereas measures that reduce greenhouse gas emissions often also reduce other environmental impacts.

The main causes of negative environmental impacts related to transport at events can be summarized in three groups:

1. Attendees (spectators, staff, athletes / artists, team, etc.) have to travel to the destination of a physical event (arrival and departure). In the case of major events, most attendees will also not come from the immediate vicinity of the venue.
2. Transportation of materials and equipment, usually delivered by vans and trucks. The environmental impact varies greatly depending on the type and size of the event.
3. The transportation of attendees within the event. Event participants of, for example orienteering events, must travel to the different stages where the competitions take place (Scrucca et al., 2016). The trip is usually made by private vehicles or buses, especially in rural areas.

As diverse as events are, so are the intensity and type of negative environmental impacts. Nevertheless, various studies showed that the transport sector accounts for the largest share of CO₂ emissions for most events, regardless of size and type. Although not necessarily outdoor events, the following table gives a good impression (for further details regarding transportation impacts of orienteering sport see Chapter 4).

Table 1: Comparison of CO₂ emissions from travel for events of different scales

Event	Scale (attendees)	% share transport / travel of the events total CO ₂ emissions	Source
2010 FIFA World Cup	Mega (700 000)	86%	Econ Pöyry AB, 2009
Arizona Homecoming	Large (60 000)	80%	Edwards et al., 2016
2014 World Orienteering Championship	Medium (6500)	70%	Scrucca et al., 2016
Regional Basketball game in BC, Canada	Small (665)	73%	Dolf et al., 2011

3.2 Direct environmental impacts

Various environmental impacts can be observed in outdoor events related to trampling (e.g. hiking, running), which, however, also depend on whether existing trails are used, or cross-country movement takes place. Especially off-track sports, such as trail running or orienteering, pose the risk of disturbing wildlife or causing damage to vegetation (Trendafilova, 2011). With a larger number of participants in an event, this risk increases even more. In addition, running cross-country, as well as running on trails, can lead to soil erosion. The International Orienteering Federation (IOF) identifies the most significant environmental impacts related to nature as trampling of vegetation, disturbance of large mammals and disturbance of birds (Parker, 2005). Marion et al. (2016) adds that especially high visiting numbers during an event can lead to vegetation impact, impact on soil, littering, erosion or impact on wilderness. The most significant direct environmental impacts caused by various outdoor events are discussed below.

3.2.1 Impacts on vegetation and soil

Trampling of vegetation is caused in particular by running cross-country and is therefore one of the most significant impacts of running events such as orienteering. A fundamental distinction can be made between three different types of impact. First, trampling can damage sensitive flora, so that it either does not recover or recovers only very slowly and may be outcompeted by other species. Further, visual quality may be reduced if, for example, vegetation is visibly damaged. Finally, another danger is that

trampling creates new routes, which may then be used by others in the future, becoming unwanted and unplanned trails (Zealand, 1990 as cited in Parker, 2005). One of the largest studies conducted on the environmental impacts of orienteering in Sweden was conducted as early as 1972. The study examined three orienteering events in southern Sweden that had participant numbers ranging from 1 300 to 9 300. The impact study, which included monitoring of nature and its recovery two years after the events, showed that after two growing seasons 90% of the damaged vegetation studied had recovered (Kardell, 1974 as cited in Parker, 2005; McCullough et al., 2018). Based on events with up to 10 000 participants, this study concludes that vegetation recovers quickly in this climate despite being trampled by participants.

In addition to natural events such as wildfires, strong wind, rainfall or flooding, soil erosion can also be caused by outdoor events such as mountain biking or running, regardless of whether they take place on existing trails or cross-country (Thurston and Reader, 2001). Soil erosion refers to the removal of soil particles, which can lead to the degradation of soil and the loss of fertile land. Soil erosion is a problem because it can cause increased pollution, sedimentation and obstruction of waterways, negatively impacting fish and other species. Damaged soil can also often store less water, which increases the risk of flooding (WWF, n.d.). Soil protection concerns are important for outdoor event sustainability.

Trails are important infrastructure for a wide range of outdoor activities and events, including but not limited to e.g. hiking, trail running, mountain biking, horseback riding, etc. Research on the impacts of trails on soil erosion is limited, but evidence suggests that running trails may have a high potential for soil erosion due to the great speed and energy exerted on the soil (Creagh et al., 1998; Salesa & Cerdà, 2020). Active and repeated use of mountain trails can lead to loss of soil fertility and soil degradation (Quinn et al., 1980). The impacts of trail use can include loss of soil moisture, detachment of soil particles, and change in chemical properties of water and soil (Hawkins & Weintraub, 2011). However, there is also evidence that vegetation can recover quite quickly if the trails are not repeatedly used (Hogg & Ingwersen, 2012; Mendoza, 2008).

Using the example of the running trail of L'Alcúdia de Crespins, it has been analyzed that trail running, in this case in the mountains, can trigger high erosion rates, sometimes double the value scientifically considered sustainable and much higher than erosion rates caused by forest fires, and by extreme rainfall events (Salesa & Cerdà, 2020). However, due to the increased number of people within a short period of time, it could potentially be concluded that this effect is amplified by events. Especially in the mountains, trail running can lead to the removal of almost all soil in areas with shallow soils (Salesa & Cerdà, 2020). In addition, mountain biking can also lead to a significant impact on the soil and erosion, for example through trail widening. However, Pröbstl-Haider et al. (2017) elaborate in this context that the extent of the impact strongly depends on local conditions, with steep descents and wet environments generally subject to stronger negative impacts. When trying to compare the impact of mountain bikers with that of runners or hikers, Evju et al. (2021) found that there were no significant differences in the extent of impact on vegetation and soil. However, this would also be difficult to analyze because they often move on the same trails.

The presence of vegetation along trails is another significant factor affecting the magnitude of soil erosion. Goeft and Alder (2001) elaborate that impact related to trail use is particularly high when there is no vegetation along the trail. Plants on and along trails can reduce trail-related soil erosion. In line with this, Salesa and Cerdá (2020) recommend that vegetation should be an essential feature in the creation and design of trails.

In conclusion, outdoor events such as mountain biking and running can have significant impacts on vegetation and soil erosion. Soil erosion is a problem that can lead to a loss of fertile land, increased pollution, and sedimentation in streams and rivers, affecting the natural environment and the species that live in it. It is therefore essential to consider the possible contribution of outdoor events to soil erosion and take preventive measures, such as designing trails with vegetation in mind.

3.2.2 Disturbance of wildlife

Another set of environmental impacts that outdoor events can have on nature is the disturbance of wildlife. Outdoor recreation, such as trekking, can disturb wildlife, both directly and indirectly by altering habitats through impacts such as trampling (Blanc et al., 2006). Disturbance is a general direct environmental impact caused by outdoor recreation and therefore outdoor events. According to Crisafulli et al. (2015, p. 1266), disturbance in ecology generally describes "any relatively discrete event in time that disrupts ecosystem, community, or population structure, and alters resources, substrate availability, or physical environment." It should also be noted that not every wildlife species responds in the same way to disturbance from recreational activities, and that different types of activities may exert different impacts. Blanc et al. (2006), for example, roughly distinguishes between visit activities such as photographing or walking with a dog and sportive activities such as biking, trekking or skiing, although it is difficult to classify activities according to their disturbance levels, as this also depends on their intensity, frequency, type of exercise and local conditions. Many activities also aim to be in an area of natural character, which is often wildlife habitat and therefore related to potential disturbance. The risk of disturbance is increased when activities take place off-track (Blanc et al., 2006). Patonnier (2000 as cited in Blanc et al., 2006) found that off-track skiers, for example, have a higher risk of causing disturbance of wildlife in larger areas.

Wildlife disturbance can lead to a number of negative effects. One of the most obvious effects is a change in animal behavior, which may involve disruption of regular movement as well as stress and flight. Often, this is based on the distance between the source of disturbance, therefore a human activity for example, and the affected animal as an indicator of the animals' susceptibility to disturbance (Blanc et al., 2006). Another indicator is the time it takes animals to return to their original activity (Madsen & Fox, 1995). Although these effects cannot be generalized, Gill et al. (2001), have analyzed that the types of animals that do not show escape responses may be the most vulnerable to disturbance because they lack possible alternative strategies.

Sutherland (1996) further clarifies that disturbance, such as that caused by outdoor recreation, can affect the natural distributions of wildlife. This includes in particular the increase of animal densities in refuge areas, which can lead to a shortage of food and thus to a disturbance of the natural competition. In this context, Blanc et al. (2006) confirm that disturbance from outdoor activities can affect and alter the spatial distribution of wildlife and thus reduce the overall carrying capacity of habitats, which would be equivalent to habitat loss. Although some wildlife may be able to adapt to disturbance under some circumstances, the overall consequences of disturbance by human activities should be considered as negative. Studies have shown that wildlife populations generally seek shelter or leave the area when disturbed and, in some cases, return after the disturbance has ended (Liddle, 1997; Jeppesen, 1984).

Naidoo and Burton (2020) elaborate that moose and bears in particular can be negatively impacted by mountain bikers. In addition, small animals such as amphibians and reptiles can be run over on the trail. Fundamentally, however, there is not too much difference between the impact of mountain bikers and that of hikers or runners.

Birds can be particularly sensitive to human presence. Research on this has focused particularly on trail-use, with mixed results. According to Bösch et al. (2018), one reason for this may be that it is difficult to distinguish between direct human impacts and those caused by habitat alteration (e.g., trail creation). However, when considering the differential impacts of recreation in heavily used (high-recreation-level) versus less frequently used (low-recreation-level) forests, species richness and bird density were found to be significantly reduced near trails. Bösch et al. (2018) specify that in heavily used forests, the reduction was -13% near trails and -4% slightly further away. In contrast, such a change was not evident in less frequently used recreational forests. In this study, Bösch et al. (2018) further cite that this effect is not due to trail creation and thus habitat alteration but directly due to recreational activities such as walking. This direct effect of human impacts through recreation was also supported by previous studies. For example, Bösch et al. (2017) found that even low intensity recreational activities are sufficient to negatively impact bird life. This is accompanied by the fact that highly sensitive bird species in particular avoid proximity to trails in any type of forest, while less sensitive species are mainly affected by trails in highly frequented areas. Further, the temporal component must be considered. In particular, during the period of territory establishment in spring, disturbance by humans may have a greater impact on bird populations, especially because human activities are associated with habitat degradation and the fact that humans can further be seen as predators that may influence breeding site selection (Bösch et al., 2017).

In Sweden, the behavior of moose and deer during orienteering events was investigated in several studies in 1979 and 1980, with participant numbers ranging from 600 to 2 000. The effects described above were also observed in these studies. The deer reacted to the presence of the athletes and left the area or sought shelter in neighboring areas. However, they returned to their original habitat within a short time (Jeppesen, 1984). The competition areas were planned in such a way that areas outside the competition trails were kept clear to serve as a refuge for the animals. At the same time, trails were planned to run in the same direction to avoid repeated encounters between animals and athletes coming from different directions (Parker, 2005). A difference between deer and

moose was observed in that moose tended to move away from the affected area, whereas deer tended to seek shelter within the area, such as in designated refuge areas. The studies showed that populations returned to their original areas within 24 hours, although some animals showed signs of stress (Parker, 2005). Codes of conduct, guidelines and checklists can mitigate negative impacts of outdoor activities on wildlife (for specific measures taken by orienteering sport in Sweden to mitigate direct impacts see 5.3.2).

To summarize, outdoor activities such as hiking, running, or mountain biking generally have an impact on wildlife. Numerous studies focusing on individual activities suggest that outdoor events can also disturb wildlife. The findings from individual activities can be applied to larger-scale events, although the impact is expected to be more concentrated and intensified. Understanding the environmental and wildlife impacts of recreational activities is crucial for modifying participant behavior and overall event planning.

3.3 Resource management

Resource management focuses on the use of materials, products for food and beverages before and during an event, as well as the handling of waste and the consumption of energy and water. The use of resources varies depending on the type of event, number of participants and local conditions, but a more general overview of the environmental impacts of the use of resources for an event is given below.

3.3.1 Materials

The avoidance of plastic materials is an issue that is increasingly attracting the attention of entrepreneurs and consumers. The use of plastic materials entails several problems. First, plastic is made from petroleum products, which require fossil fuels. This has a negative impact on the climate, especially with the amount of plastic produced worldwide. Another major problem is that plastic is not biodegradable. Instead, it breaks down into smaller pieces, so-called microplastics, that can then get into organisms. Müller et al. (2012) elaborates that out of 267 marine species, almost a third had ingested plastic. Plastic pollution therefore poses an immense threat to the environment, especially to animals. For this reason, efforts should be made to avoid plastic pollution and minimize plastic use in general. EU Directive 2019/904 on single use plastic aims to further reduce plastic waste.

Using the example of orienteering events, Parker (2005) elaborates that instead of disposable plastic bottles, glass bottles were provided to the participants, which were then collected and returned to the mineral water manufacturer. This prevented plastic waste, and therefore plastic items, from entering the environment. Plastic can also be hidden in other products that are often used at events, such as merchandise or giveaways.

The same attention should be paid to the use of paper products before and during an event, for example for printed event programs. Paper production and usage can be harmful to the environment and is often linked to deforestation for its production, which can alter or degrade forest habitats. In addition, the production of paper causes the emission of greenhouse gases and contributes to the pollution of air and water. Given the current state of technology, a great amount of information can be communicated through digital channels, reducing paper usage and thus contributing to a more sustainable event.

In addition to the consumption of plastic and paper, non-permanent structures are also part of the resources of an event, for example, structures that serve the course of a competition and are only erected for this purpose. Parker (2005) elaborates that in the context of orienteering competitions, care is taken to ensure that the structures can be dismantled again and are not only used once but can be borrowed from sport event hire companies and returned after the event. Elements that are not available as standard, such as stands for results lists, were made from standard wood, which was dismantled for recycling at the end of the competition. Such measures can ensure that as few products as possible are used for one-time use, thus contributing to the sustainable use of materials.

In summary, the negative impact of plastic and paper on the environment is a growing concern for entrepreneurs and consumers and further restrictions, non the least coming from EU directives, will come into force. Plastic, in particular, poses a significant threat due to its non-biodegradable nature and potential harm to aquatic life. It is crucial to reduce and reuse plastic and paper usage and explore sustainable options, such as digital communication. Sustainable practices in event planning can contribute to a cleaner and healthier environment and responsible use of resources.

3.3.2 Waste

Waste management is the most frequently mentioned environmental challenge when it comes to events. This includes pollution to all environmental components – soil (e.g. landfill deposit of garbage, liquid pollutants), water (e.g. sewage, pollutant runoffs), air (e.g. gas and coal-powered energy sources). Event literature focuses heavily on the importance of waste reducing, reusing and recycling strategy before, during and after the events (e.g., Fenich et al, 2014; Westerbeek et al., 2005; Ali-Knight et al., 2008; Bowdin et al., 2006; Gibson & Connell, 2012; Goldblatt, 2010; 2013; Hall & Sharples, 2008; Lienhard, & Preuss, 2014; Mair, 2018). It would not be an exaggeration to claim that waste management has been to a large extent equated with environmental impact management when it comes to events.

In the tourism and event sector, food waste is often discussed, which is an important issue given that 88 to 100 million tons of food waste are generated in Europe every year (FUSIONS EU, 2016). According to Fieschi and Pretato (2017), 12% of this food waste is caused by food service in the hospitality sector, which also includes indoor and outdoor events. In a study on mega events, Rajan and Booth (2016) analyzed that food waste

accounted for more than one third of the total waste stream. There are also high social, economic, and environmental costs associated with food waste because of its production, distribution, and disposal (Rajan & Booth, 2016). Razza et al. (2009) therefore elaborates that from an environmental perspective alone, using food packaging that is compostable would be the best choice.

Besides food waste, plastic waste is another type of waste that occurs in large quantities at events. Bianchini and Rossi (2021) elaborate that especially in running events such as marathons plastic waste from packaging is a problem, which is also complicated by the fact that participants consume products during the race and the resulting plastic waste may be spread over long distances. Sorting and recycling of plastic is often considered an appropriate method but is complicated by the fact that plastic must be separated into recyclable and non-recyclable plastic, otherwise sorting and recycling becomes difficult and expensive (Bianchini & Rossi, 2021). Eriksen et al. (2019) add that the diverse characteristics of plastics and thus the lack of standardization limit the recycling potential.

There are numerous waste management initiatives in the context of sporting events. Many aim to recycle or compost waste. However, Bianchini and Rossi (2021) note that due to the variety of different waste products, e.g. different types of plastic waste, the correct collection and sorting cannot always be guaranteed, which in the worst case can have negative effects on the environment instead of the intended positive effects. In this context, Atcharyasopon (2017, as cited in Bianchini & Rossi, 2021), for example, found that in a soccer match in the Thai league, more than 85% of the waste generated was not properly sorted and sent to landfill. As elaborated by Bianchini and Rossi (2021), proper separation into the different types of plastic requires greater effort, but it can also result in better recycling outcomes.

From an ecological point of view, events therefore benefit from a maximum amount of easily compostable food (to reduce food waste) and the use of compostable tableware (to reduce plastic waste), as this also reduces both carbon and water footprint (Fieschi & Pretato, 2017). At the same time, this is only useful if the efficiency of collecting, sorting and recycling waste during an event is improved. For events, it is also helpful to be aware of the type and amount of waste generated and to adapt waste management accordingly, both for one-day and multi-day events. Rajan and Booth (2016) also elaborate that efforts to reduce waste will be more successful if there is greater awareness of the content of the waste. In addition, the events studied have shown that the waste containers provided were sometimes inappropriate for the venues, which can be attributed to the amount of waste being too large for this purpose (Rajan & Booth, 2016).

In the study conducted by Bianchini and Rossi (2021), which aimed to improve the efficiency of plastic waste during an outdoor event, the important role of volunteers during an event came to light. Volunteers were instrumental in encouraging participants to properly dispose of the waste generated. They did not do the actual disposal, but acted as trainers for the public and communicators about the issue. It is, therefore, important to engage volunteers into raising environmental awareness and disseminating codes of conduct at events.

In conclusion, waste management is a critical issue that must be addressed by event organizers. Food waste and plastic waste are two major types of waste that are generated in large quantities at events, and their management can have significant social, economic, and environmental costs. Efforts to reduce waste and improve waste management can be successful through the use of compostable materials and efficient collection, sorting, and recycling processes. Volunteers play a crucial role in encouraging proper waste disposal, and event organizers should be aware of the type and amount of waste generated to adapt waste management accordingly. Additionally, greater awareness of waste content and appropriate waste container provision can contribute to effective waste management practices. Overall, proper waste management can lead to a cleaner and healthier environment and a more responsible use of resources in the event industry.

3.3.3 Energy

Energy is an important component for the successful implementation of an event. The type of energy used is therefore an important factor in the sustainability of the event. Today, most of the world's energy production is based on fossil fuels, which include coal, oil, and natural gas. These fossil fuels are particularly harmful in part because their extraction and combustion contribute significantly to air pollution and release toxic emissions that harm both health and climate (Harvard T.H. Chan School of Public Health, n.d.). Therefore, in contrast to non-renewable energy sources that will eventually be exhausted, it is more reasonable from a sustainability perspective to use renewable energy sources such as wind, water, sunlight, or geothermal heat for an event.

Events in particular, unlike the average daily use, cause a significant increase in energy consumption. The University of London (citing MeetGreen, n.d.), states that a three-day event with 1 000 attendees consumes approximately 530 tons of oil to power the entire event. This high energy demand results in high CO² emissions, which in turn emphasizes the importance of more sustainable, renewable energy sources. Energy is needed for machinery, lighting, and transportation, among other things, and the amount of energy used depends largely on the venue of an event and the infrastructure that is used (e.g., sports hall or arena) (Broadbent & Ramsak, 2022). According to the University of London research (n.d.), the main sources of energy consumption during an event fall into the following categories:

- General energy consumption (e.g. energy for running the venue, hotel accommodation, etc.)
- Travel to and from the event (car/train/plane)
- Goods transportation (transport of materials needed for an event)
- Food and beverages (procurement, transport, preparation)

In order to make an event more sustainable in terms of energy consumption, it is therefore advisable to first obtain an overview the energy sources used. In addition, where possible, non-renewable energy sources should be replaced with sustainable

energy sources. Especially outdoor events in summer can take advantage of this rather than indoor events (University of London, n.d.).

Broadbent and Ramsak (2022) state that World Athletics events, e.g., the associated indoor and outdoor track and field events, strive to increase energy efficiency in order to reduce CO₂ emissions, guided by a "LEGO" energy hierarchy approach. It involves eliminating unnecessary energy use (e.g., by turning off unneeded equipment), using energy-efficient equipment (e.g., LED lighting), especially using renewable energy to generate electricity and store energy (e.g., biofuels, solar power), and then offsetting the remaining emissions through appropriate offset programs. For all these measures, however, continuous monitoring of energy consumption is also important in order to keep improving efficiency.

The Commonwealth Games 2022 can be mentioned as another example. Their goal was to reduce CO₂ emissions as much as possible through appropriate measures. The unavoidable emissions were offset by planting new forests. In addition, energy from solar panels was used and employees were encouraged to switch off equipment when not in use. In terms of transportation to and from the event, each ticket allowed free use of public transportation and admission to events was only granted upon presentation of an e-ticket (Broadbent & Ramsak, 2022). This example shows a few measures that can save energy without too much effort and thus reduce the CO₂ emissions of an event.

In conclusion, energy is an essential component in the successful execution of outdoor events. The use of non-renewable energy sources such as coal, oil, and natural gas can contribute significantly to air pollution, release toxic emissions that harm both health and climate, and lead to high CO₂ emissions. Therefore, it is important to prioritize the use of sustainable energy sources like wind, water, sunlight, or geothermal heat for outdoor events. By implementing measures such as reducing unnecessary energy use, using energy-efficient equipment, and offsetting unavoidable emissions through appropriate programs, the energy consumption of events can be made more sustainable. It is crucial for event organizers to prioritize sustainability in energy consumption and continuously monitor and improve efficiency to reduce the environmental impact of events.

3.3.4 Water

Water is one of our most precious resources and needed by all of us on a daily basis. It is therefore particularly alarming that water scarcity is already a major global problem affecting millions of people every year (Mekonnen & Hoekstra, 2016). Only about 2.5% of the world's water supply is freshwater, of which most is stored in glaciers and permanent snow covers. Finally, 0.7% can be considered as accessible drinking water, coming from ground, streams or lakes (Shiklomanov, 1991). A growing number of humans will need more freshwater in the future, not only for drinking, but also for agriculture. In addition, water pollution from consumption, land use and wastewater will increase. Impacts from global warming are a further factor reducing the amount of drinking water available (Shiklomanov, 1991). SDG 6 - Ensure availability and

sustainable management of water and sanitation for all - formulates the need for sustainable water management to achieve long-term water security (United Nations, 2022).

When considering the potential negative environmental impacts of events in the context of water as a resource, it must first be clarified that humans need and pollute water daily, regardless of whether they spend the day at an event or in their everyday life. The circumstances of the water consumption are decisive. Especially for outdoor events, it might be difficult to maintain the same water quality standards as in an everyday environment. Most often than not there is no availability of tap water or toilets connected to the sewage system. As a result, environmental impacts can occur in the form of unnecessary water waste, poor wastewater disposal, paper and plastic waste, and possible pollution of watercourses that do not occur to the same extent in an everyday environment (Dávid, 2009; Bianchini & Rossi, 2021). In addition, certain events require irrigation, such as the maintenance of slopes for cross-country and alpine skiing events, which can involve huge water consumption (Rutty et al., 2015).

Natural environments include rivers, streams or wetlands, which play an important role in the ecosystem and for drinking water supply. As event participants move freely in the terrain, potential disturbances to these sensitive water ecosystems could occur. In Finland, for example, certain streams and springs are protected under Finnish forestry law. If such areas are located in the venues of orienteering events, the planners will place the controls not only outside the declared areas, but also in such a way that the logical route choices do not pass through them (Parker, 2010). While there are no studies on possible pollution of watercourses by orienteering events at the current state of knowledge, these measures of Finland are exemplary and could avoid negative impacts and thereby contribute to SDG 6.6.

In a recent International Orienteering Federation (IOF) survey, all IOF member countries were questioned about the status of typical environmental issues associated with orienteering events in their countries (IOF, 2023). When asked about the importance of different environmental aspects, wastewater treatment was seen as the most important aspect next to trampling of vegetation and wildlife disturbance. Interestingly, further results of the survey showed that only a few countries have to consider national environmental legislation regulations for wastewater management at orienteering events. In a list of various aspects to be considered, wastewater management was ranked 10th out of 11. There is a clear gap between the relevance and the regulations that need to be followed regarding the environmental impact of wastewater.

Beside countless caravans, a large number of mobile toilets will be situated at the arenas and campsites of major orienteering events. Mobile toilets and holding tanks of RVs often use a variety of chemicals. This kind of sewage is harmful to nature and must be specially treated. That might explain the important role of wastewater management for the sustainability of orienteering events, especially since a lack of adequate regulation could exacerbate negative impacts. On the other hand, the adoption of waterless outhouses and portable toilets that use recycled water and biodegradable and non-toxic cleaning products/chemicals is much more water-efficient than traditional flush toilets.

This presents an opportunity for sustainable action (Anand & Apul, 2014). Since many campers and participants do not have a permanent water supply, there can be an increased amount of plastic and paper waste from water consumption, similar to the already mentioned running events where plastic waste due to packaging and beverage stations causes a major impact (Bianchini & Rossi, 2021).

However, according to current knowledge, the potential negative environmental impacts on water are rather small compared to other impacts of orienteering and have not been sufficiently researched. Scrucca et al. (2016) listed several categories for water conservation and reuse when evaluating the 2014 World Orienteering Championships but declared all of them as not relevant to the event.

To conclude, sustainable water management is necessary to achieve long-term water security, as highlighted by SDG 6. Outdoor events like orienteering competitions can negatively impact water resources, including wastewater management, water waste, and watercourse pollution. When planning such events, it's important to consider SDG 6 targets such as improving water quality and protecting water-related ecosystems. Finland's measures to avoid negative impacts on protected areas could contribute to SDG 6.6, as an example. Wastewater treatment is a crucial aspect of orienteering events, and sustainable alternatives like should be considered. To ensure long-term water security, the potential negative impacts of outdoor events on water resources should be considered when planning them, even though further research is necessary.

3.4 Best practices of environmental impact management

Evaluating the sustainability performance of events is important to ensure that events are not only successful but also sustainable. Event management should therefore have a clear strategy of planning for and evaluating its impacts, as well as apply tools and methods to measure and improve their sustainability performance.

3.4.1 Plan-do-check-act

Plan-Do-Check-Act (PDCA) is a widely recognized method in various industries, including event planning and management (Isniah et al., 2020). The method comprises four phases: Plan, Do, Check and Act, which are repeated in a cycle to achieve continuous improvement. It is an effective approach for every planning aspect related to events and can therefore also be used to increase sustainability. In the planning phase (Plan), event organizers set sustainable goals and strategies, such as reducing waste or increasing the use of renewable energy sources. In the implementation phase (Do), these strategies are implemented and executed. The control phase (Check) evaluates the effectiveness of the strategies and measures progress towards achieving the goals. This is often done after an event. Finally, in the action phase (Act), adjustments can be made

based on the evaluation results to improve the sustainability of the event (Johnson, 2002). By applying the PDCA method, event organizers can continuously improve the sustainability of their events over time.

3.4.2 Certifications and measures

To achieve sustainable goals, set in the planning phase, certifications and measures can be used to help assess and address the environmental impact of events. These tools are particularly useful in determining the environmental effects of events and ensuring they are managed in a sustainable way (Hall & Page, 2012; Getz & Page, 2015; Kaplanidou & Gibson, 2010). Certifications and measures are essential in ensuring that events are sustainable and have minimal negative impacts on the environment and the surrounding communities. For instance, event organizers can use certifications such as ISO 20121, which is an international standard that specifies the requirements for a sustainable event management system (Collins & Cooper, 2017). The ISO 20121 certification provides a framework for event organizers to manage the social, environmental, and economic impacts of their events. However, using tools such as GDP growth, cost-benefit analysis, or other economic models to measure the impact of events provides a broad and overall assessment of the event, but cannot draw conclusive evaluations on cultural and environmental factors (Dwyer & Jago, 2012). As this report deals with the environmental impact of events, the following section presents some recognized and commonly used tools that enable the measurability of negative impacts to a certain extent.

3.4.3 Environmental impact assessment (EIA)

Environmental Impact Assessment (EIA) is a common process for assessing environmental impacts of proposed projects, policies or activities. In the context of events, an EIA can be a valuable tool for event planners to identify the environmental impacts of their events and assess ways to mitigate or minimize these impacts (Scrucca et al., 2016; Bond et al., 2012). Potential risks such as noise pollution, air pollution, waste generation can be identified and recommendations made to minimize these risks, such as using renewable energy sources, reducing waste through recycling and composting systems or venue choice. An environmental impact assessment can also help event planners to identify potential opportunities for positive environmental impacts, such as incorporating sustainable practices into the design and operation of the event. This may include using environmentally friendly resources or working with local organizations and suppliers.

Measurability is enabled, for example, by an environmental baseline study, which collects and analyses data on the current state, or by impact identification/prediction, which analyses the location and design of the event or uses simulations and other

techniques to predict the likely effects of the event on the environment (Ortolano & Shepherd, 1995).

3.4.4 Life cycle analysis (LCA)

Life cycle analysis (LCA) is another important tool for understanding the environmental impact of events by assessing the environmental impact of a product or service from cradle to grave. In the context of events, LCA can be used to assess the impact of most aspects of an event isolated or combined, including materials used, transport, energy consumption and waste management (Edwards et al., 2016). Direct environmental impacts are however often hard to measure.

By conducting an LCA, event organizers can get an accurate overview of overall consumption of resources and identify opportunities to reduce environmental impacts. LCA can also help to make informed decisions about trade-offs between different environmental impacts, such as between greenhouse gas emissions and water consumption. In summary, LCA is an important tool for sustainable event management and provides an accurate analysis of negative impacts, which is often also required for certification or offsetting. Nevertheless, it should be noted that collecting the data needed for such an assessment can be difficult and time-consuming (Edwards et al., 2016).

3.4.5 Carbon footprint

The carbon footprint tool is a tool that can help events to estimate the amount of greenhouse gas emissions that are generated through activities, operations, and supply chains. The tool uses data on energy consumption, transportation, waste management, and other factors to calculate the carbon dioxide equivalent emissions associated with these activities (Minx et al., 2009). It can help event organizers to measure the environmental impact of the event and identify areas where improvements can be made to reduce the carbon footprint. However, there are a large number of different carbon footprint software programs that do not use a uniform methodology or algorithms for the final calculations, which limits the possibilities for comparison between them (Gibson & Wong, 2011). As Gibson & Wong (2011) further point out, there is also some uncertainty regarding their accuracy or applicability to different types of events, as they vary greatly in terms of activity and resulting environmental influences.

3.4.6 Ecological footprint

Compared to the carbon footprint, the ecological footprint (EF) is capable to account for the direct and indirect resource use associated with the running of an event as well as the resulting environmental impacts that occur outside the event site (e.g. the travel of the visitors) (Collins et al., 2009; Wackernagel et al., 2019). "The Ecological Footprint is a resource accounting tool that provides a proxy measure of the global environmental pressures related to human resource use. It provides a quantitative assessment of the amount of bio productive land required to provide the resources used by a defined population, and to assimilate the wastes produced (i.e., CO₂ emissions), using prevailing technologies and resource management practices." (Collins & Cooper, 2017, p. 151). The most commonly used method to measure the ecological footprint is the Ecological Footprint Analysis (EFA) developed by Wackernagel and Rees. In addition to the carbon footprint, it includes food, housing, transportation, goods and services, and land use. The final standardized unit of measurement is called global hectares (gha) which represents the average biologically productive area of land and water needed to produce the resources consumed (Wackernagel & Rees, 1998).

Compared to EIA and LCA, which often provide detailed information on specific environmental impacts, EF offers a broader and more holistic view of the overall sustainability of human activities. While the EF can thereby help to address some of the problems of other environmental assessment methods, it does not offer a complete sustainability assessment. It is for example not able to consider freshwater consumption, soil erosion and impacts due to the release of long-lived toxic substances or the depletion of non-renewable resources (Bastianoni et al., 2013).

The methods presented here are primarily based on measurable data such as CO₂ consumption, water or energy consumption. However, as discussed in previous chapters, outdoor events often have direct impacts on the environment that are difficult to measure, such as wildlife disturbance, soil impact, and vegetation impact. Therefore, zoning and carrying capacity are established measures to reduce or prevent direct impacts on the environment, caused by events.

3.4.7 Zoning

Zoning is a measure that helps to manage the impact of events on the environment by dividing the event space into different zones. This division is done based on the type and intensity of activities that will take place in each zone. Some activities may be allowed in certain zones, while others may be restricted or modified to reduce their impact on the environment. By using zoning measures, event organizers can control and minimize the negative impact of their events on the environment and the surrounding communities (Leung & Marion, 1999). For instance, zoning can be used to restrict certain activities that may have a severe impact on the vegetation and wildlife or permit activities that have minimal or no impact on the environment. Zoning measures can

help event organizers to manage the environmental impact of their events and reduce potential negative effects on the surrounding communities.

3.4.8 Carrying capacity

Carrying capacity is another established measure that is used to estimate an acceptable number of visitors within a specific area and provides useful information for management in specific places (Bell et al., 2007). Carrying capacity measures are important in managing the social and environmental impacts of events. The carrying capacity measures can provide useful information on the number of people that can be accommodated in a specific area without causing harm to the environment, wildlife and the surrounding communities. By using carrying capacity measures, event organizers can ensure that their events do not exceed the limits that the environment can support.

In summary, there are a variety of methods and tools that can measure, compare, mitigate, and avoid the environmental impacts of events. However, despite increasing interest in improving the sustainability of events and festivals, there is currently no consensus on the methods to assess sustainability (Ballarano et al., 2022) and it is therefore often difficult to compare events sustainability efforts. In addition, each approach/method has its strengths and limitations. The best possible results in reducing environmental impacts can thus be achieved primarily by combining different tools.

Table 2. Overview of practices and tools of environmental impact management of outdoor events

Tool / Measure	Short Description
Plan-Do-Check-Act	Plan-Do-Check-Act (PDCA) is a management method for continuous improvement, consisting of four stages: plan a change, implement it, monitor its effects, and adjust accordingly.
Certifications and measures	Certifications such as ISO 20121, which is an international standard that specifies the requirements for a sustainable event management system, can provide a framework for event organizers to manage the social, environmental, and economic impacts of their events.
Environmental impact assessment (EIA)	Environmental Impact Assessment (EIA) is a process that evaluates the potential environmental effects of a proposed event, to identify and mitigate any negative impacts on the environment.
Life cycle analysis (LCA)	Life Cycle Analysis (LCA) is a methodology that assesses the environmental impact of a product or service throughout its entire life cycle, from raw material extraction to disposal. Results can be used to understand the environmental impact of an event.

Carbon footprint	Carbon footprint of events refers to the amount of greenhouse gas emissions, mainly carbon dioxide, produced by the activities associated with an event, including transportation, energy consumption, and waste management.
Ecological footprint	Ecological footprint of events refers to the measure of the impact of an event on the natural environment, including land use, water consumption, and carbon emissions, which can lead to resource depletion and ecological damage.
Zoning	Zoning events refers to the practice of designating specific areas or zones for events in a given geographical location, to regulate noise levels, traffic flow, and especially potential impacts on the surrounding environment.
Carrying capacity	Carrying capacity of events refers to the maximum number of people or level of activity that a particular event location or venue can support without causing negative impacts on the environment (and community or infrastructure).

4. ORIENTEERING SPORT

4.1 History, definitions and typologies

Orienteering is a sport that originated in Sweden in the late 19th century. The first orienteering competition was held in 1897 (in Norway) and consisted of a map and compass race through the woods. The sport quickly spread throughout Scandinavia and Europe, and in 1961, the International Orienteering Federation (IOF), representing 10 European nations, was founded to govern and promote the sport worldwide. Since then, the IOF has supported the creation of many national orienteering federations and currently has 78 national member federations (IOF, n.d.).

The orienteering sport involves navigating through unfamiliar terrain using a topographic map with standardized symbols and a compass. The map contains control points that have to be ticked off in a certain order, starting with the purple arrow and ending with the double circle. Anything which is permanently located on the ground and could serve as a control point or navigational aid is marked on the map¹ (see Fig. 1 and 2). This includes boulders, natural ground features, vegetation, water bodies and man-made features such as fences or buildings. Although completing the course in the shortest possible time is the decisive factor for winning a competition, the shortest distance is not always the fastest (Orienteering Ireland, n.d.). Therefore, the sport requires a combination of physical fitness, map-reading skills, concentration and strategic planning, making it a challenging and exciting affair for athletes and enthusiasts alike.

¹ See an example of an orienteering competition map and its explanation:
<https://www.orienteering.ie/orienteering-maps-explanation/>



Figure 1 An orienteerer with a map (photo by Axel Eriksson)



Figure 2 A control point (photo by Axel Eriksson)

There are different types or variations of orienteering. It can be practiced on foot, by bicycle, with skis or even with assistive vehicles. The four main forms in which competitions are held are:

- Foot Orienteering: This is the most common form of orienteering, where participants navigate freely through a designated course on foot using a map and compass (includes off-track activities).
- Ski Orienteering: In ski orienteering, participants navigate through a designated course on cross-country skis using a map and compass. This variation is popular in Nordic countries where skiing is a common winter sport (includes off-track activities).
- Mountain Bike Orienteering: In mountain bike orienteering, participants navigate through a designated course on a mountain bike using a map and compass. This variation is popular in countries with varied terrain and mountain bike culture.
- Trail Orienteering: Trail orienteering is a variation of the sport that is designed for participants with physical disabilities. In this version, participants use a map and compass to navigate through a designated course that is marked with tape or flags (Orienteering USA, n.d.).

4.2 Using nature as a playground

Orienteering competitions can in principle be held in all environments and terrains. Even city centers where, for example, benches, litter bins, sculptures and other objects common in urban parks can serve as control points would be a possible location. For

example, the European Orienteering Championship races in 2023 took place in Verona, Soave and Vicenza, Italy – all in urban terrain with narrow streets and fast and challenging route choices (<https://orienteering.sport>). However, orienteering originated and grew in the forests and valleys of Scandinavia, where a vast natural spaces can be used. Traditionally, orienteering has therefore taken place predominantly in natural, rural environments (Scrucca et al., 2016).

Nature is also an ideal setting for orienteering as it offers diverse and complex terrain, including forests, hills, mountains, wetlands and even urban parks. These varied environments provide an excellent backdrop for orienteering with different levels of difficulty. Furthermore, the terrain in nature is constantly changing due to factors such as weather conditions and seasonal changes, which can make orienteering even more challenging and exciting. The unpredictability creates surprises and excitement, which makes the event even more attractive for participants. Natural landscapes, often with special features that offer aesthetic enrichment, such as scenic landscapes, but also physical challenges, such forests or mountains, make the route particularly appealing for runners. At the same time, they often represent the sensitive habitat of animal and plant species, which leads to the next section.

4.3 Specifics of orienteering sport and events

Orienteering is a unique sport that differs from many other sports in several ways. Participants of orienteering competitions have to navigate through unfamiliar terrain and make quick decisions while running at high speed (Scrucca et al., 2016). Furthermore, orienteering is a self-paced sport, meaning that participants can choose their own route through the course and are not required to follow a specific path. This allows for greater creativity and strategic thinking and sets it apart from most other outdoor sports such as running or cycling, which typically have a designated, marked course.

Due to the specifics of this sport, the environmental impacts of orienteering may also differ from other sports. While negative impacts from waste, transport, water and energy consumption are likely to be similar to other kinds of outdoor events such as trail running, direct impacts on the environment will differ if participants are allowed to move freely and predominantly unrestricted in nature. However, comparing to other usage of natural areas, the impacts from orienteering are more dispersed in space and contained in time.

The extent to which wildlife or vegetation is affected in the short and long term by free-moving runners has been investigated only to a small extent. For example, Čākurs (2019, as cited in Straupe & Ivbule, 2022) elaborates that in an event with 1 825 participants, a significant trampling effect could only be seen in the short term and vegetation recovered after only one month. The largest effect due to trampling was observed on mossy soil and on dunes and hills. Straupe and Ivbule (2022) similarly elaborate, in the context of an event in coastal pine forests, that orienteering does not significantly affect the forest floor. The further away from the control points the impact occurred, the less

significant it was, with the impact most clearly seen on moss layers. On the other hands, Salesa and Cerda (2020) or Ng et al. (2018) report significant land degradation and erosion from trail running events in the mountains, where the impact was stronger than from naturally occurring events.

From the available studies it could therefore be argued that orienteering is a relatively low-impact activity since it does not require the construction of permanent infrastructure or the modification of the environment in the form of trails (at least for orienteering on foot) leading potentially to less soil erosion, compared to other outdoor events. However, this does not mean that environmental impacts attributed to orienteering are completely negligible. There is also high variation in terms of ecosystem resilience specifics. Overall, there is a lack of research on this topic and fragmented case studies make any generalizations difficult. For example, there are no studies on whether those negative environmental impacts are also consistently small and short-term for large orienteering events.

In summary, orienteering is a sport that originated in Sweden has since spread globally, with 78 national member federations currently recognized by the IFO. It involves navigating through unfamiliar terrain using a topographic map and compass, with participants required to tick off control points in a certain order. Orienteering competitions can be held on foot, with skis, on a mountain bike, or in a trail version designed for participants with physical disabilities. While orienteering can be held in any environment, it traditionally takes place in natural, rural environments, where nature provides diverse and complex terrain. The sport is unique in that participants are not required to follow a specific path and can choose their own route, allowing for greater creativity and strategic thinking. While some of the environmental impacts of orienteering are similar to other outdoor events, the extent to which wildlife or vegetation is affected by free-moving runners is inconclusive. Dispersion of orienteering impacts over the terrain and limitation of these impacts to the timeframes of the event add a unique dimension to environmental impacts of orienteering. Overall, orienteering offers a challenging and exciting experience for athletes and enthusiasts alike with a potential to promote a deeper appreciation and understanding of the natural world.

4.4 Transport-related impacts

Orienteering sport in relation to tourism and sustainability is fundamentally underrepresented in research. As far as the negative effects on the environment are concerned, according to current knowledge, there are only a few scientific publications that mainly refer to the ecological effects on flora and fauna. A detailed overview is given in chapter 3.2 dealing with the direct impacts of outdoor events. Negative impacts of traffic and travel at orienteering events were only discussed in the report on the 2001 World Orienteering Championships in Tampere, Finland (IOF, 2002), and an academic article by Scrucca et al. (2016), applying a new method to assess the sustainability performance of events on the example of the 2014 World Orienteering Championships (WOC). Another source of information, which however only provides a rough

indication of possible negative impacts and no specific measurements, is the Touristekonomisk Rapport (report on the tourism economy) of O-Ringen Uppsala 2022 (Upplevelseinstitutet, 2022). Based on these three available documents, the potential negative environmental impacts of transportation and travel at orienteering events can only be roughly classified.

Scrucca et al. (2016) used the carbon footprint indicator (CF) as the only tool to measure the environmental impact of the 2014 WOC. Although an event's CF is a key factor for sustainability, it is certainly not the only one to consider. However, when examining the transportation impacts of events, measuring CF alone is a common practice, often as part of a life cycle analysis (Cooper & McCullough, 2021; Triantafyllidis et al., 2018; Collins et al., 2009; Edwards et al., 2016). Results show that 64.5% of the total carbon emissions at the 2014 WOC were due to transportation, including the transport of athletes and staff (about 3000) and participants (about 3500).

The second most significant category was the running of the event itself, accounting for 35.06% of total emissions. Transportation by shuttle buses is considered a subcategory of "running the event", yet it could also be seen as transportation, increasing the 64.5% to almost 70%. The small remaining percentage was attributed to the marketing and organization of the event (Scrucca et al., 2016). An orienteering World Cup is of course different from O-Ringen in terms of the number of attendees and the type of event. Nevertheless, the study shows that, similar to other sporting events, orienteering events generate a high proportion of total emissions from the transport sector.

Although not very recent, the 2001 WOC environmental audit report shows that minimizing energy consumption and emissions from transportation was a high priority for orienteering events more than 10 years ago - "Goal 4: Minimizing energy consumption and emissions" (IOF, 2002). During the event, parking for private cars as well as bus shuttles to the different event sites was offered which were free of charge for organizers, athletes and other staff. Despite that, results showed that neither the organizers nor the spectators were particularly interested in using public transport. "Over the several days of the championships a total of 500 trips were made by bus, a very low figure considering the overall spectator total was between 20 000 – 25 000." (IOF, 2002, p.5) Even if the report only considered intra-event transport, which causes less environmental impact than arrival and departure transportation, its findings show that the attempt to reduce emissions by providing environmentally friendly means of transport was not successful.

The report on the economic impact of O-Ringen Uppsala 2022 did not aim to include aspects of sustainability, it does however include statistics that are of interest regarding the environmental impact. The event attracted roughly 22 600 visitors (of which 20 000 event participants and 2 600 accompanying visitors) (Destination Uppsala, 2022). The vast majority (74%) were from Sweden, while the remaining 26% were from other predominantly European countries, with Norway taking the lead (6%) (Upplevelseinstitutet, 2022). The already significant number of O-Ringen attendees from abroad is likely to further increase in the future due to the aforementioned internationalization of events. One possible sign of this could be the increase in air travel to O-Ringen, which would be an interesting topic for further research. 17% of the

participants arrived to Uppsala by plane while in previous years of O-Ringen events this share was lower (7% in 2017, 3% in 2018, and 4% in 2019), (Upplevelseinstitutet, 2022), which could most likely be explained by the proximity of the venue to the main international airport Arlanda.

Table 3: Share of different arrival modes for O-Ringen Uppsala 2022

Mode of Transport	% share of total arrivals	Compared to average share of the years 2017-2019
Car / Caravan	76%	14.6% decrease
Airplane	17%	12.4% increase
Train	13%	6% increase
Boat / Ferry	6%	-
Bus	6%	4.7% increase
Live in Uppsala / Other means of transport	5%	-

Source: Upplevelseinstitutet, 2022

However, positive changes in transport mode choice for arrivals to O-Ringen can also be seen in Table 3. The percentage of total arrivals is above 100% since it was possible to click on a combination of different means of transport for arrival in the survey. Compared to the average amount of the years 2017-2019, the percentage of car / caravan arrivals in 2022 decreased by 14.6%, while the number of train and bus arrivals increased. Without considering electric powered cars, 19% of the attendees arrived by sustainable modes of transport to O-Ringen 2022. An additional 5% lived in Uppsala or travelled by other means of transport not presented (Upplevelseinstitutet, 2022).

In conclusion, there is a lack of research on the relationship between orienteering sport and tourism sustainability. The limited available research indicates that transportation and travel have a significant negative impact on the environment during orienteering events. The carbon footprint is a common tool used to measure the environmental impact of transportation at events. Orienteering events generate a high proportion of total emissions from the transport sector. Attempts to reduce emissions through providing environmentally friendly means of transport at the event have not been successful. The report on the economic impact of O-Ringen Uppsala 2022 provides statistics indicating that the number of international attendees is likely to further increase in the future (Upplevelseinstitutet, 2022). Positive changes in transport mode choice for arrivals and departures to O-Ringen can also be observed, with the percentage of car/caravan arrivals decreasing and train and bus arrivals increasing. Overall, more research is needed to better understand the impact of orienteering events on the environment and to find ways to make these events more sustainable.

4.4.1 Challenges of sustainable transportation

Sustainable transportation can be seen as the movement of people and goods in an environmentally, socially, and economically sustainable way (Greene & Wegener, 1997; OECD, 1996). Furthermore, no mode of transport can be fully sustainable. Electric cars and buses require lithium-ion batteries whose production and disposal leaves a carbon footprint, while future demand could further overshoot the available resources needed for the production (Notter et al., 2010; Wanger, 2011). A train requires rails (land use), causes noise pollution and is a potential threat to wildlife and vegetation. Compared to cars and airplanes, however, it doesn't emit greenhouse gases directly, requires a less extensive road network, pollutes soil and water due to e.g., fine dust much less, and has a higher passenger capacity. In addition to the fundamental reduction of traffic volume, it is particularly important to switch to means of transport that have a lower impact on the environment than the use of private vehicles and airplanes (Smith et al., 2019; Page, 2005). When considering sustainable transport for orienteering events, the first priority is to improve the current situation, for example by reducing car and air traffic.

Research has demonstrated the importance of a concrete PLAN- DO-CHECK-ACT approach (discussed in chapter 3.4) for each aspect related to an event (Isniah et al., 2020). Looking at the transport aspect of orienteering events, a significant reduction in emissions can already be achieved in the planning phase ("PLAN"). Therefore, event organizers need to define and follow clear sustainability principles and base decisions on sustainable actions from the beginning (Scrucca et al., 2016; Ballarano et al., 2022). Orienteering venues can be selected based on whether train and bus connections are available, if possible. Ahead of the event, organizers can further encourage visitors to travel by available public transport instead of promoting the use of park-and-ride facilities for events (Collins & Flynn; 2008).

In the "DO" phase, the goal of sustainable transportation is to ensure high standards during the event and minimize impacts related to emissions and congestion by implementing best practices (Ballarano et al., 2022). Results of the WOC 2001 environmental audit report showed however, that the sole provision of sustainable transport (e.g. shuttle buses) during the event is not sufficient to trigger sustainable behavior of visitors (IOF, 2002). The use of nudging², the creation of incentives and the setting of norms must be integrated.

In order to "ACT" more sustainably at the next event, it is important to "CHECK" the impact after an event by measuring and comparison. While many events, including O-Ringen, work with sustainable certification standards, there is a lack of agreement on the methods to assess the sustainability of transport at events (Ballarano et al., 2022). In general, the diversity of events hampers the development of generalizable methods. The market is flooded with certification standards and, in addition to the pure calculation of

² Nudging is a concept in behavioral economics and psychology that involves using subtle changes or cues to gently influence people's behavior towards making better choices without limiting their freedom of choice. Nudging can be applied at events to influence attendees' behaviors towards certain desired outcomes such as encouraging sustainability (McCoy et al., 2018). For example, placing interesting-looking recycling bins in visible locations and making them easily accessible can nudge attendees towards recycling.

CF, there are other quantitative, qualitative as well as mixed method approaches to measure and value the impact of events which are further elaborated in chapter 3.5.

Overall, sustainable transportation is crucial for reducing the environmental impact of orienteering events. While no mode of transport is fully sustainable, it is important to prioritize means of transport with lower environmental impacts. A Plan-Do-Check-Act approach is useful to implement in order to achieve sustainable transportation in orienteering events, with event organizers needing to follow clear and defined sustainability rules and principles from the beginning. Nudging, incentives, and norms can help encourage sustainable behavior among visitors during events. Measuring and comparing the impacts is also important for continuous improvement of sustainable transportation solutions at events.

5. ORIENTEERING IN SWEDEN

Outdoor recreation is a part of the Swedish lifestyle and with 81 000 registered participants, orienteering is one of the most popular activities. In fact, Sweden is where this sport originated and enjoys high popularity, ranging from a family activity over a serious leisure activity to international competitions. (World Orienteering Championships) (Svenska Orienteringsförbundet, 2021b). Orienteering first appeared in Sweden as a form of military land navigation training using a map and compass., the The first public orienteering event in Sweden took place in 1901, preceded by intra-military games. Nowadays, Sweden is one of the countries where orienteering is the most developed, which besides its history could also be due to the right of public access (*allmansrätten*), as mentioned by the Swedish elite orienteer Oskar Sjöberg (Duquenne, 2018).

In Sweden, the constitutional right of *Allmansrätten* guarantees the freedom to visit nature, allowing citizens and foreigners to experience the outdoors without any obstruction as part of the public sphere (Beery, 2013). This right of public access is an essential feature of several Nordic European countries. It serves as both, as a means of limiting land ownership while also providing the public with outdoor recreation opportunities. Furthermore, some commercialized companies operate within the same public sphere on equal terms (Fredman & Tyrväinen, 2010). This provides also the opportunity to compete in the forest, which is not necessarily possible in other countries. Landowners and rights holders are further obliged to tolerate actions that can be carried out within the scope of the right of public access. The placement of orientation posts is for example something that the landowner can tolerate as long as they are placed in a suitable location, only there for a short period of time, and reassembled after the event (Naturvardsverket, n.d.)

There are exceptions, especially for events that take place in nature. In order to protect nature and wildlife in the best possible way, the Swedish Environmental Protection Agency published a new guidance for arrangements in nature in 2022, called “Arrangemang i naturen”. When an organization plans, for instance, a large orienteering event that requires considerable interference with nature in the form of clearing vegetation and/or extensive ground stabilization, this no longer falls under the right of public access. A consultation with the district administration and the consent of the landowner are then usually required (Naturvardsverket, 2022).

In 1938 the Swedish Orienteering Association (Svenska Orienteringsförbundet - SOFT) was formed making it the oldest national orienteering federation in the world. Prior to that, orienteering was classified under general sports. SOFT provides an information platform for the sport, develops business, strategy and sustainability plans for Swedish orienteering and coordinates competitions as well as national teams in the four sub-disciplines orienteering (on foot), ski orienteering, mountain bike orienteering and precision orienteering. In 2021, the SOFT had 548 member associations within 23 districts (Svenska Orienteringsförbundet, 2021a).

While more than 500 official orienteering competitions are organized nationwide, including district, national, international and championship competitions, about 2 000 simpler so-called close competitions, which are a form of training competitions, are also held. Despite Covid-19, 1 426 events were held in 2021 counting over 242 000 registered participants. Although already considerable, it does not reflect the full potential and interest in the sport of orienteering. In 2019, before the event industry collapsed due to Covid-19, the number of registered participants in Swedish orienteering competitions (excluding O-Ringen) exceeded 480 000 (SOFT, 2021b).

In summary, Orienteering is a popular outdoor recreational activity in Sweden with a rich history. Sweden is considered one of the countries where orienteering is most developed, due in part to its right of public access laws. The Swedish Orienteering Association (SOFT) was formed in 1938 and coordinates competitions as well as national teams in various sub-disciplines. Over 500 official orienteering competitions are organized nationwide, with many more simple training competitions held. Despite the Covid-19 pandemic, over 242 000 registered participants attended 1 426 events in 2021 alone. In 2019, the number of registered participants in Swedish orienteering competitions exceeded 480 000.

5.1 Kompassriktning 2030 and sustainability strategies in Swedish orienteering

It is expected that Swedish orienteering sport will grow over the next few years. Considering that Sweden has about 10.4 million inhabitants in 2021, SOFT members will represent almost 1% of the Swedish population in 2024. One of the overall goals for 2030 is described as “more and more”.

Table 4: Orienteering membership growth target

	Orienteers	Members	Orienteering association in municipalities
2021	183.000	82.000	88%
2024	200.000	100.000	90%
2030	300.000	150.000	100%

Source: Svenska Orienteringsförbundet. (n.d.c)

More orienteering will be arranged and organized in all different forms, such as more training sessions, competitions, leisure activities and training courses (Svenska Orienteringsförbundet, n.d.a). The extent to which the growth in activities and events is

leading to an increase in negative environmental impacts, and the extent to which more is being done to address these in the coming years, is an issue that needs to be explored. The SOFT aims to work with the sustainability concept according to Brundtland (United Nations, 1987) having three dimensions being equally important for developing Swedish orienteering and achieving the goals towards 2030.

Overall sustainability objectives for 2030 are:

- By 2030, Swedish orienteering will be one of the leading players in the world of sport in terms of economic, social and environmental sustainability.
- In 2030, members of orienteering sport reflect the population of Sweden, and everyone has the same opportunities to participate in orienteering activities.
- In 2030, orienteering events are carried out in a sustainable way with regard to the environment and nature (Svenska Orienteringsförbundet, n.d.a).

Narrowing down to environmental sustainability, SOFT's focus areas for 2023-2024 are education and support for associations and organizers. Next to operating according to the Swedish orienteering sustainability policy, cooperation with stakeholders and research institutions are to be prioritized. In this context, all organizers should receive training in the Swedish Environmental Protection Agency's guidelines for events in nature by 2023 till 2024. Active participation in research will further be carried out on sustainable sport and outdoor life through MISTRA Sport & Outdoors and the project "Double Impact - reducing emissions and increasing accessibility in sport", funded by Vinnova (Svenska Orienteringsförbundet, n.d.a).

In general, Swedish Orienteering's sustainability policy is based on the three pillars of sustainability and makes use of the Framework for Strategic Sustainable Development (FSSD), one of the most proven approaches available in the field of sustainability (Broman & Robèrt, 2017). In total, Swedish orienteering's sustainability policy contains nine conditions that describe threshold values for a sustainable society from an environmental, social and economic perspective. However, this digression only refers to the environmental criteria, as this report is concerned with the environmental impact of events. The three environmental sustainability criteria are:

1. Reducing the use of fossil fuels and metals and gradually transitioning to renewable energies and circular use of metals by (Svenska Orienteringsförbundet, n.d.b)
2. Use of sustainable products (Svenska Orienteringsförbundet, n.d.b)
3. Physical degradation (help to support important ecosystem services) (Svenska Orienteringsförbundet, n.d.b)

In conclusion, the Swedish orienteering sport is expected to experience significant growth over the next few years, with a goal to represent almost 1% of the Swedish population in 2024. However, the potential negative environmental impacts of this

growth must be considered and addressed. The Swedish Orienteering Federation (SOFT) has set ambitious sustainability objectives for 2030, including becoming a leading player in sport sustainability, reflecting the population of Sweden, and carrying out events in a sustainable way. To achieve these objectives, SOFT has established a sustainability policy based on the Framework for Strategic Sustainable Development and containing nine conditions for a sustainable society. For the environmental criteria, the focus is on reducing the use of fossil fuels and metals, using sustainable products, and supporting important ecosystem services. SOFT's focus areas for 2023-2024 are education and support for associations and organizers, cooperation with stakeholders and research institutions, and training organizers in the Swedish Environmental Protection Agency's guidelines for events in nature. By taking a comprehensive and proactive approach to environmental sustainability, the Swedish orienteering sport aims to achieve its growth objectives while minimizing its negative impact on the environment.

5.2 O-Ringen: The largest orienteering event

Every year since 1965, Sweden has hosted the world's largest orienteering competition named *O-Ringen* (www.oringen.se). The five-day competition usually attracts around 20 000 participants and several thousand accompanying visitors. Participants of all ages ranging from 5 to 95 come from about 40 different countries, although the majority are from Sweden. Compared to other sporting events, orienteering events like O-Ringen are just as suitable for families as they are for the world's elite orienteers. Since the event is always scheduled in calendar week 30, only summer competitions can be held, which are 1. Foot-O; 2. Elite Tour; 3. MTBO and Trail-O (O-Ringen AB, 2022). In July of 2023, O-Ringen took place in Jämtland Härjedalen region in Sweden (various orienteering disciplines taking place in Östersund, Åre, Trillevallen, Järpen, Ånn, Mörsil, Vålådalen) attracting around 15 000 participants (see Fig. 3-6)





Figure 3-6 O-Ringen in Jämtland Härjedalen in 2023 (photos by Axel Eriksson)

During the upcoming five-year period of 2021-2025 O-Ringen has the vision to not only be the largest orienteering event but also a well-known sustainable experience. In order to fulfill this pioneering role as a major sustainable event, the work focuses on three areas - sustainability, experience and profiling (O-Ringen AB, 2020).

Since 1999, O-Ringen has been an eco-labeled event, and since 2019, it has also been a certified sustainable event under the Greentime Standard certification. Greentime uses 146 questions/criteria for certification based on the SDGs, 55 of which relate to environmental sustainability. It involves various factors such as waste management, energy consumption, transportation, water usage, and other relevant aspects related to environmental impact. To be certified as a sustainable event, the event must fulfill 38 mandatory questions and collect at least 60% of the overall points. Furthermore, as O-Ringen is 100% owned by SOFT, the rules and targets of the Swedish Orienteering's sustainability policy mentioned previously apply to the event (O-Ringen AB, 2021). In addition, the O-Ringen 2021-2025 Strategic Plan lists other goals that contribute to the SDGs and are cross-cutting for the event (O-Ringen AB, 2020):

SDG 12: "Responsible consumption and production"

- Reduce the total amount of waste and food waste by 25% by 2025 (compared to 2019) and then halve by 2030.

SDG 13: "Climate change"

- Reduce emissions 25% per category by 2025 (compared to 2019) and then halve by 2030.
 1. Transport of goods before and during O-Ringen
 2. The participants' transport to O-Ringen
 3. Bus transport of participants during O-Ringen

SDG 15: "Life on Land"

- No lasting damage to ecosystems and biological diversity in our competition areas

In summary, O-Ringen strives to be a global leader in the delivery of environmentally sustainable outdoor events. The Swedish Orienteering Sustainability Policy and O-Ringen's Sustainability Strategy for 2021-2025 address the negative environmental impacts associated with nature-based events. In addition, O-Ringen has been recognized as an eco-labeled event and certified according to the Greentime standard. The organization has set ambitious goals for responsible consumption, emissions, and use of natural resources, and therefore could serve as a showcase event for sustainably run orienteering events. The extent to which these goals are achievable, feasible and sufficient to minimize negative environmental impacts and which implications this has for orienteering is discussed further.

5.3 Implications for orienteering events

Analyzing the environmental impacts of orienteering events is an important step towards promoting sustainability within the sport. The collaboration between O-Ringen, the world's largest orienteering event, and the Green Time certification program provides valuable data and insights into assessing and addressing environmental aspects associated with such events. By examining the available data from O-Ringen 2022 and combining it with existing literature, it is possible to gain a better understanding of the environmental impacts of orienteering events in general. This approach allows for identification of potential areas for improvement in future events. It is important to note that O-Ringen serves only as an example within orienteering for this analysis, since it is currently the only one assessing and reporting data on its environmental impacts.

5.3.1 Transportation

Transportation and travel are main factors of environmental impact during outdoor events (Pereira et al., 2017). Attempts to reduce emissions through providing environmentally friendly means of transport have not been particularly successful and there is a need for more research to better understand the impact of transportation to and at orienteering events on the environment, and to find ways to make the impact less significant.

Swedish Orienteering Federation has issued guidelines on arranging climate-smart events (SOFT, 2019). These include recommendations on the choice of venue with availability of public transport as well as behavior incentives (encourage carpooling and public transport use).

According to the data of Greentime, O-Ringen 2022 had taken measures to reduce the impact of transportation (Greentime, n.d.). These measures included promoting climate-smart travel options such as trains, commuter trains, buses, and bicycles. They also provided information on how participants could reach the competition arenas by bike or on foot, and selected event locations that were easily accessible using climate-smart transportation. During the event, the use of electric hybrid cars for event staff and transportation of goods for longer journeys was implemented, and the placement of arenas near bus and train stops was prioritized. However, it is worth noting that a climate analysis has not been conducted yet due to resource and financial constraints.

The choice of location near a major transportation hub, close to train and bus stations, may have resulted in an increase in train and bus arrivals to Uppsala. This is a positive development as it promotes sustainable transportation options and reduces reliance on individual car travel. This challenge of internationalization and long-haul tourist arrivals will be difficult to address for large orienteering events but likely plays a minor role for smaller events.

While there is still a lack of research and challenges in reducing emissions, the measures taken during O-Ringen 2022 serve as concrete examples of promoting more sustainable travel and event planning for orienteering. It further underscores, in compliance with the analyzed research, the importance of continuing to develop and implement transportation solutions in orienteering events with the incorporation of different impact management tools.

5.3.2 Direct environmental impacts

Outdoor events are associated with a number of environmental impacts that can be mitigated to various degree. The preservation of soil as an example is important not only for the natural environment but also for humanity as soil is a valuable resource. It is, therefore, necessary to balance the enjoyment of outdoor events with the protection of natural resources to ensure their sustainable use for future generations. It's important to be aware of and minimize those direct impacts as they can harm the natural environment, causing long-term consequences like soil erosion and harm to wildlife. Striking a balance between enjoying and protecting the environment involves e.g. designing and using trails with vegetation in mind, closing competition areas for wildlife refuges, and scheduling activities around sensitive mating seasons of wildlife and especially birds, as stated in e.g. the SOFT guidelines (1996; 2015) or the Swedish Environmental Protection Agency recommendations (Naturvårdsverket, 2022).

In Sweden efforts to mitigate negative impacts on wildlife have been reflected e.g. in the principles and guidelines of Swedish Orienteering Federation, which include organizing orienteering events outside of animal breeding seasons, creating wildlife-friendly trails and providing environmental education for orienteers (SOFT, 1996; 2015). Special agreement between landowners, orienteering and hunting organizations summarizes principles of conduct to minimize negative impacts on wildlife (SOFT, 1996). SOFT also issues checklists for nature-friendly orienteering event organization,

including the choice of control points, and pays attention to sensitive biotopes. A special set of recommendations can also be found in the report regarding events in nature by Swedish Environmental Protection Agency (Naturvårdsverket, 2022).

However, it's important to note there is often insufficient data on possible measures taken to minimize direct environmental impacts of outdoor events, such as disturbance of wildlife. While this does not necessarily mean that such measures were not considered, the lack of transparency in communication raises questions about the extent to which organizers as well as participants prioritize these aspects. Future attention therefore should be paid to communication of efforts in minimizing direct environmental impacts to ensure transparency and accountability.



Figure 7-8. Examples of eroded trails in Jämtland Härjedalen (photos by Axel Eriksson)

In terms of the impact on soil, research on the longitudinal impact of trails on erosion is still limited. Existing research suggests that both mountain biking and running can have negative impacts on soil, such as soil erosion and degradation (Hawkins & Weintraub, 2011). Outdoor events contribute to trail erosion (see e.g. Fig. 7-8), however, as previously mentioned, there is also evidence that vegetation can recover quite quickly if the trails are not continuously intensely used (Hogg & Ingwersen, 2012; Mendoza, 2008). It has to be emphasized, however, that orienteering events often use already existing trails, meaning that negative impacts cannot be attributed solely to orienteering. With the growing popularity of outdoor activities many events frequently share the same space and infrastructure. The cumulative effects of multiple events raises the need to use the natural resources in collaboration with other stakeholders in mind.

Consequently, future orienteering events need to be aware and take measures to minimize their impact, especially in sensitive ecosystems.

5.3.3 Resource management and materials

Sustainable resource management includes among others effective and efficient use of materials. In the reviewed literature, reference is mostly made to the negative impact of plastic and paper on the environment. Reducing the usage of plastic and paper is crucial, especially because of plastic's non-biodegradable nature and potential harm to aquatic life. Sustainable alternatives like digital communication should be explored. In the context of orienteering events, this discussion often involves the use of plastic tableware (plastic cups) and informational materials (Parker, 2005). The sustainability analysis of O-Ringen 2022 for example mainly refers to the aspects Goods & Services and Chemicals in connection with resource management and materials. Thereby it emphasizes the importance of working with environmentally certified suppliers and reducing the total environmental impact, including through the use of recyclable or environmentally friendly goods. With regard to the use of chemicals, it encouraged the use of eco-labeled soap and cleaning products, as well as minimizing emissions and waste generation. For example, event participants were encouraged to bring their own washing powder for the washing machines, which are connected to the municipal water supply. In terms of paper use, the data suggests that while the event prints 34 000 magazines annually, it relies primarily on digital marketing and advertising. In addition, some of the goods used, such as fabric for officials, name badges, and backstage passes, are only partially recyclable or produced in an environmentally friendly manner. Regarding the use of plastic materials, paper cups were used at the hydration stations and wooden cutlery at the kiosk.

Future orienteering events can benefit from this experience by implementing similar sustainable practices to avoid the use of plastic and paper products as much as possible. They can consider using alternative materials such as glass bottles instead of plastic bottles and avoid paper programs by using digital communication channels. For structures that are needed for the event, for example setups for result lists, tables etc., organizers can borrow and return them to minimize one-time use and wastage. It is also important for event organizers to educate participants and raise awareness about sustainability and the impact of their actions on the environment. They can encourage participants to bring their own reusable water bottles and reduce their use of disposable products during the event. By taking these steps, orienteering events can reduce their environmental impact and promote sustainable practices also in terms of use of resources.

5.3.4 Waste management

Proper waste management, particularly in relation to food and plastic waste, is crucial for outdoor events as mismanagement can lead to social, economic, and environmental costs. To reduce waste and improve waste management, Razza et al. (2009) propose using compostable materials and applying efficient collection, sorting, and recycling processes. Volunteers further play a crucial role in encouraging proper waste disposal, and event organizers are advised to be aware of the type and amount of waste generated to adapt waste management accordingly (Bianchini & Rossi, 2021).

The organizers of O-Ringen 2022 have taken their cue from the experience of previous years and adapted the waste management accordingly. Waste was sorted into different categories, including glass, deposit, paper packaging, plastic packaging, combustible, paper, metal, and food waste. In some areas with small amounts of waste, only three categories were sorted. The waste contractor and event's waste manager were in direct contact to supplement and adjust the number of containers as needed, depending on attendance and waste generation. A waste recycling officer was responsible for ensuring that waste disposal was efficient and environmentally correct. Officials made sure that containers were in place before the event and that they were emptied throughout the day. Litter pickers were also deployed to maintain a clean environment.

The implications of waste and waste management for future orienteering events are significant. Organizers must consider the type and amount of waste generated during an event, including food, paper, and plastic waste. The waste management strategies implemented by the organizers of O-Ringen 2022 can serve as a model for future orienteering events. Sorting waste into different categories can make the collection and disposal of waste more efficient and environmentally friendly. Having direct communication between the waste contractor and the event's waste manager, as well as having a dedicated waste recycling officer, can ensure that waste disposal is done correctly and efficiently. Additionally, having officials responsible for ensuring that containers are in place and that they are emptied throughout the day, as well as deploying litter pickers, can help maintain a clean environment during and after the event. These strategies can help reduce the negative impact of waste generated by orienteering events on the environment and contribute to a more sustainable future.

Furthermore, it is suggested to use compostable materials and encourage proper disposal of waste by participants. Volunteers can play an important role in educating participants about waste management and encouraging proper disposal. Overall, waste management must be a top priority for event organizers in order to minimize negative environmental impacts and promote sustainability.

5.3.5 Resource management: Energy and Water

Energy consumption and water management are crucial considerations for the sustainability of orienteering events. Non-renewable energy sources can lead to air

pollution and high CO² emissions, emphasizing the need to prioritize sustainable energy sources like wind, water, sunlight, and geothermal heat. Organizers can reduce energy use, employ energy-efficient equipment, and offset unavoidable emissions through appropriate programs to make energy consumption more sustainable. The Commonwealth Games 2022 serves as an example, employing practical measures such as solar panels, equipment power-saving practices, and free public transportation to significantly reduce CO² emissions (Broadbent & Ramsak, 2022).

Sustainable water management is also essential to ensure long-term water security. Outdoor events like orienteering competitions have the potential to impact water resources, necessitating consideration of Sustainable Development Goal (SDG) 6 targets during event planning. Sustainable wastewater treatment alternatives, such as waterless outhouses and portable toilets using recycled water and non-toxic cleaning products, should be considered. Care must be taken to avoid disturbing sensitive aquatic ecosystems by placing controls away from designated watercourses and springs and ensuring that logical route choices do not pass through them.

Although specific information on the consideration of sensitive water areas in orienteering events is limited, O-Ringen made efforts towards sustainable energy and water use. Using eco-labelled electricity was considered when available and feasible. Water conservation measures included monitoring shower usage, encouraging participants to practice responsible campsite hygiene, and providing portable toilets without flushing and biodegradable, non-toxic cleaning products/chemicals. They also aimed to reduce shower water usage through the use of specific showerheads that operate only when held. Furthermore, O-Ringen explored the use of LED lights for stages to enhance energy efficiency. These sustainable measures aimed to reduce the event's environmental impact and promote eco-friendly practices among participants (Greentime, n.d.). Overall, orienteering events can adopt relatively simple measures to reduce negative impacts on water and electricity. It is further important to note that smaller-scale events generally have a smaller and more manageable impact compared to larger events.

6. CONCLUSIONS, RECOMMENDATIONS and FUTURE RESEARCH

The purpose of this report was to provide a comprehensive overview of the environmental impacts associated with outdoor events, with a specific focus on orienteering. The study identified various potential impacts, including greenhouse gas emissions, land and water pollution, soil erosion, damage to vegetation, and disturbance to wildlife. The report aimed to address the existing research gap regarding the environmental impacts of outdoor events and offered recommendations to enhance their sustainability based on current literature, using orienteering as a showcase example.

There is limited research on outdoor events and ecological sustainability, but it suggests that transportation and travel to and during outdoor events have the most significant negative environmental consequences. Current efforts to reduce emissions through environmentally friendly transport options have not been successful enough. However, sustainable transportation plays a vital role in mitigating the environmental impact of outdoor events such as orienteering. Prioritizing transportation alternatives with lower environmental impacts, by e.g. locating venues and competition areas near public transport stations can contribute to climate change mitigation. Implementing incentives for behavior change, such as sustainability rules and pledges, codes of conduct, nudging, to encourage sustainable behavior among event visitors and participants should also be considered. Notably, the world's largest orienteering event O-Ringen has already implemented measures to promote climate-smart travel options like trains, buses, and bicycles, while further prioritizing event locations near public transportation stops. Measuring and comparing impacts over time is crucial for continuously improving sustainable transportation solutions, employing various tools and practices of environmental impact management.

Outdoor events like mountain biking and running can lead to significant soil erosion, resulting in the loss of fertile land, pollution, and sedimentation in water bodies. To mitigate soil erosion during outdoor events, protecting the soil through trail design is deemed essential. As orienteering is primarily an off-trail activity resulting in unique negative impacts on nature due to the high number of participants moving freely, soil erosion plays a minor role. Orienteering events can mainly disrupt wildlife habitats, trigger watercourse pollution and damage vegetation, underscoring the importance of planning and conducting events with consideration for wildlife and nature. Swedish Orienteering Federation provides examples of guidelines, checklists and policy documents aimed at concrete actions to mitigate orienteering-related impacts. Implementing measures such as closing certain areas for wildlife refuges and designing trails with vegetation in mind can help mitigate these impacts. However, there is a need for greater transparency regarding the efforts taken by all event organizers to address these impacts, including zoning and carrying capacity considerations.

This report also recognizes the growing concern over the negative impact of resource use on the environment, highlighting the importance of reducing their usage and

exploring sustainable alternatives to plastic and toxic materials in outdoor events. Responsible waste management practices, including composting and recycling, opting for alternative materials, and promoting digital communication channels are a few ways to mention. O-Ringen serving as an example for orienteering events, works actively with environmentally certified suppliers and tries to reduce the environmental impact by using recyclable or environmentally friendly goods. O-Ringen further implements waste separation and dedicates personnel for efficient waste disposal. Educating participants about proper waste disposal can be advantageous for future orienteering events. There is also room for improvement in sustainable resource management, such as greater involvement of local food suppliers at different venue locations and the implementation of stricter food product regulations.

The use of non-renewable energy sources in outdoor events contributes to air pollution and high CO² emissions. Prioritizing sustainable energy sources and implementing energy-saving measures can make event energy consumption more environmentally friendly. Outdoor events can also have a negative impact on water resources, emphasizing the necessity of sustainable water management for long-term water security. There are various methods and tools available to measure, compare, mitigate, and avoid the environmental impacts of events. Currently, however, there is no consensus on uniform sustainability assessment methods, which is why the combination of different tools may provide the best results.

Overall, orienteering events like O-Ringen are a vivid example of how outdoor events can strive to become more sustainable while also demonstrating the potential of orienteering as a sustainable outdoor activity. That said, orienteering events can still further reduce their environmental impact by promoting sustainable travel, carefully selecting the venue to increase public transportation, minimizing direct environmental impacts, adopting resource management practices, and implementing efficient waste management, energy, and water conservation measures. These actions contribute to the long-term sustainability of the sport and protect the natural environment.

Despite the growing interest for outdoor events and the orienteering sport, there are still several knowledge gaps and areas for future research, when looking at their environmental impact. These gaps include understanding the behavior of participants, the role of volunteers, and the inclusion social and economic sustainability of orienteering. The following are potential research ideas to address these knowledge gaps:

- Mitigation of transport-related impacts. More research and strategies are needed in the ways to promote climate-smart travel options when travelling to and from events. This includes optimal planning of event venues with accessible climate-smart transportation in mind as well as stimulation of pro-environmental behavior of the attendees. Further, transportation during the event at venues has its contribution to the event sustainability but the research in this area is lacking.
- Resource optimization and waste reduction. Investigate ways to optimize resource usage (such as energy, water, and materials) during outdoor (sport) events. Explore strategies for waste reduction, recycling, and sustainable practices to minimize the ecological footprint of these events. Future research in

this area that specifically addresses orienteering could additionally explore the tools and approaches presented in a new setting.

- Technological advancements: Investigate how innovative technologies can contribute to the sustainability of outdoor events. Explore the use of technology in course planning and design to make it easier for planners to incorporate sustainability principles. For example, develop methodologies to avoid sensitive ecological areas and minimize the environmental impact of courses.
- Collaboration and knowledge sharing: Explore possibilities for collaboration and knowledge sharing among event organizers, clubs, participants, and local communities. Foster the exchange of expertise, innovative ideas, and best practices to enhance sustainability efforts made by event organizers.
- Participant behavior and education: Explore methods to motivate and educate participants in sustainability issues related to outdoor events. Investigate the role of volunteers in promoting sustainable practices and consider ways to encourage environmentally responsible behavior among participants.
- Environmental Impact Assessment: Perform a comprehensive assessment of the environmental impacts of orienteering events. This assessment would provide insights into the key areas for improvement and help identify strategies to minimize environmental harm.
- Long-term Environmental Monitoring: Establish long-term monitoring programs to study the direct ecological impacts of orienteering events on nature over time. By observing and analyzing these impacts, researchers can better understand the long-term sustainability implications and develop effective mitigation measures.
- Alternative event formats: Research alternative event formats that can minimize the ecological footprint of orienteering events. Explore the feasibility of shorter, more localized events to reduce travel distances and emissions. Additionally, investigate virtual orienteering experiences utilizing augmented reality (AR) and GPS technologies to promote sustainability.
- Comparison of small and large-scale events: Compare the environmental impacts of small and large-scale orienteering events. Identify potential options to reduce the environmental impact of larger events through improved planning, resource management, and sustainable practices.
- Cumulative impacts: Events need to see themselves as part of a larger network of different other activities and actors in the event area. There should be stronger cooperation among multiple actors sharing the same resources.

By continuing to systematically address these knowledge gaps, conducting further research and taking practical steps in these areas, scientific community and event management will contribute to further progress towards achieving sustainability goals and minimizing the environmental impacts of outdoor events.

REFERENCES

- Agha, N.; Taks, M. (2015). A theoretical comparison of the economic impact of large and small events. *International Journal of Sport Finance*, 10(3), 199-216.
- Ali-Knight, J., Robertson, M., Fyall, A., & Ladkin, A. (Eds.). (2008). *International perspectives of festivals and events: paradigms of analysis*. Elsevier.
- Anand, C. K., & Apul, D. S. (2014). Composting toilets as a sustainable alternative to urban sanitation—A review. *Waste management*, 34(2), 329-343.
- Andersen, E.B., Børsting, B., Køhler, M., Neilsen, I., Rasmussen, J. and Sandgreen, F. (1986) 'Vejvalgsundersøgelse af 3 orienteringsløb (Route choice at 3 orienteering events).' Danish Orienteering Federation. [IOF/Env/RP007]
- Ballarano, D., Patella, S. M., & Asdrubali, F. (2022). Sustainable Transportation for Events: A Systematic Review. *Sustainability*, 14(23), 15815.
- Bastianoni, S., Niccolucci, V., Neri, E., Cranston, G., Galli, A., & Wackernagel, M. (2013). Sustainable development: Ecological Footprinting in accounting. In S-E Joergensen (Ed.), *Encyclopedia of Environmental Management*, 2467–2481.
- Beery, T. H. (2013). Nordic in nature: friluftsliv and environmental connectedness. *Environmental education research*, 19(1), 94-117.
- Bell, S.; Tyrväinen, L.; Sievänen, T.; Pröbstl, U.; Simpson, M. (2007). Outdoor recreation and nature tourism: A European perspective. *Living Reviews in Landscape Research*, 1(2), 1-46.
- Bianchini, A., & Rossi, J. (2021). Design, implementation and assessment of a more sustainable model to manage plastic waste at sport events. *Journal of Cleaner Production*, 281.
- Blanc, R., Guillemain, M., Mouronval, J., Desmonts, D., & Fritz, H. (2006). Effects of non-consumptive leisure disturbance to wildlife. *Revue D Ecologie-la Terre Et La Vie*, 61(2), 117–133.
- Boggia, A., Massei, G., Paolotti, L., Rocchi, L., & Schiavi, F. (2018). A model for measuring the environmental sustainability of events. *Journal of Environmental Management*, 206, 836–845.
- Bond, A., Morrison-Saunders, A., & Pope, J. (2012). Sustainability assessment: the state of the art. *Impact Assessment and Project Appraisal*, 30(1), 53-62.
- Bötsch, Y., Tablado, Z., & Jenni, L. (2017). Experimental evidence of human recreational disturbance effects on bird-territory establishment. *Proceedings of the Royal Society B: Biological Sciences*, 284(1858),
- Bowdin, G., O'Toole, W., Allen, J., Harris, R., & McDonnell, I. (2006). *Events management*. Routledge.
- Bravo, G. A., Shonk, D. J., Silva-Bórquez, J., & González-Mesina, S. (2018). *Sport Mega-Events in Emerging Economies: The South American Games of Santiago 2014*. Springer.
- Broadbent, C., & Ramsak, B. (2022, April 4). Delivering sustainable events: energy management. *worldathletics.org*. Retrieved March 27, 2023, from <https://worldathletics.org/athletics-better-world/news/sustainable-events-energy-management>
- Broman, G. I., & Robèrt, K. H. (2017). A framework for strategic sustainable development. *Journal of cleaner production*, 140, 17-31.
- Brownlie, S., Bull, J. W., & Stubbs, D. (2020). Mitigating biodiversity impacts of sports events. In A. Knee (Ed.), *IUCN. International Union for Conservation of Nature and Natural Resources*. Retrieved February 22, 2023, from <https://portals.iucn.org/library/node/49025>
- Burton, A., Fritz, O., Proebstl-Haider, U., Ginner, K., & Formayer, H. (2021). The relationship of climate change & major events in Austria. *Journal of Outdoor Recreation and Tourism*, 34,
- Case, R. (2012). Event impact and environmental sustainability. In: S. J. Page; J. Connell (eds.), *The Routledge handbook of events*, 362-384. Routledge.

- Cavallin Toscani, A., Macchion, L., Stoppato, A., & Vinelli, A. (2022). How to assess events' environmental impacts: A uniform life cycle approach. *Journal of Sustainable Tourism*, 30(1), 240-257.
- City of Melbourne. (n.d.). Energy efficiency. City of Melbourne. Retrieved March 27, 2023, from <https://www.melbourne.vic.gov.au/business/sustainable-business/sustainable-event-guide/Pages/energy-efficiency.aspx>
- Coaffee, J.; Shaw, T. (2005). The liveability agenda: new regionalism, liveability and the untapped potential of sport and recreation. *The Town Planning Review*, 76(2), i-v.
- Cole, D. N. (2004). Environmental impacts of outdoor recreation in wildlands. *Society and resource management: A summary of knowledge*, 107-116.
- Collins, A., & Cooper, C. (2017). Measuring and managing the environmental impact of festivals: The contribution of the Ecological Footprint. *Journal of Sustainable Tourism*, 25(1), 148-162.
- Collins, A., & Flynn, A. (2008). Measuring the environmental sustainability of a major sporting event: A case study of the FA Cup Final. *Tourism Economics*, 14(4), 751-768.
- Collins, A., Jones, C., & Munday, M. (2009). Assessing the environmental impacts of mega sporting events: Two options?. *Tourism management*, 30(6), 828-837.
- Cooper, J. A., & McCullough, B. P. (2021). Bracketing sustainability: Carbon footprinting March Madness to rethink sustainable tourism approaches and measurements. *Journal of Cleaner Production*, 318, 128475.
- Creagh, U., Reilly, T., & Lees, A. (1998). Kinematics of running on "off-road" terrain. *Ergonomics*, 41(7), 1029-1033. <https://doi.org/10.1080/001401398186577>
- Crisafulli, C., Swanson, F. J., Halvorson, J. H., & Clarkson, B. D. (2015). Volcano Ecology: Disturbance Characteristics and Assembly of Biological Communities. In *The Encyclopedia of Volcanoes* (2nd ed., pp. 1265-1284). Academic Press.
- Dávid, L. (2009). Environmental impacts of events. In *Event management and sustainability* (pp. 66-75). Wallingford UK: CABI.
- Deery, M.; Jago, L. (2010) Social impacts of events and the role of anti-social behaviour, *International Journal of Event and Festival Management*, 1(1), 8-28.
- Di Vita, S., & Morandi, C. (2017). *Mega-Events and Legacies in Post-Metropolitan Spaces: Expos and Urban Agendas*. Springer.
- Dolf M, Vigneault A, Storey S, Sianchuk R, Teehan P, Zhang S, Adams T (2011) Measuring the climate change impacts of a UBC Thunderbirds men's basketball game. Rep. University of British Columbia Centre for Sport and Sustainability
- Dredge, D.; Whitford, M. (2011). Event tourism governance and the public sphere. *Journal of Sustainable Tourism*, 19(4-5), 479-499
- Duglio, S.; Beltramo, R. (2017). Estimating the economic impacts of a small-scale sport tourism event: The case of the Italo-Swiss mountain trail CollonTrek. *Sustainability*, 9(3), 343.
- Duquenne, A. (2018). The popular Swedish sport you probably know nothing about. *The Local Sweden*. Retrieved February 22, 2023, from <https://www.thelocal.se/20180517/the-popular-swedish-sport-you-probably-know-nothing-about/>
- Dwyer, L.; Jago, L. (2012). The economic contribution of special events. In: S.J. Page; J. Connell (eds), *The Routledge Handbook of Events*, 129-147. Routledge.
- Econ Pöyry AB. (2009) Feasibility study for a carbon neutral 2010 FIFA World Cup in South Africa. South Africa Department of Environmental Affairs and Tourism & Norwegian Government, Stockholm
- Edwards, L., Knight, J., Handler, R., Abraham, J., & Blowers, P. (2016). The methodology and results of using life cycle assessment to measure and reduce the greenhouse gas emissions footprint of "Major Events" at the University of Arizona. *The International Journal of Life Cycle Assessment*, 21, 536-554.

- Eriksen, M. K., Christiansen, J. R., Daugaard, A. E., & Astrup, T. F. (2019). Closing the loop for PET, PE and PP waste from households: Influence of material properties and product design for plastic recycling. *Waste Management*, 96, 75–85.
- Eriksson, A., Pettersson, R., & Wall-Reinius, S. (2023). Environmental concerns in nature-based events: the permit process for organised outdoor recreation and sport. *Scandinavian Journal of Hospitality and Tourism*, 1-19.
- Evju, M., Hagen, D., Jokerud, M., Olsen, S. L., Selvaag, S. K., & Vistad, O. I. (2021). Effects of mountain biking versus hiking on trails under different environmental conditions. *Journal of Environmental Management*, 278, 111554.
- Fenich, G. G. (2014). *Planning and management of meetings, expositions, events and conventions*. Pearson Higher Ed.
- Fieschi, M., & Pretato, U. (2017). Role of compostable tableware in food service and waste management. A life cycle assessment study. *Waste Management*, 73, 14–25.
- Foroughi, B., Shah, K. a. M., Nikbin, D., & Hyun, S. S. (2014). The impact of event quality on fan satisfaction and game attendance in the context of professional soccer in Iran. *International Journal of Sports Marketing & Sponsorship*, 15(3), 40–56.
- Fredman, P. & Tyrväinen, L. (2010). Frontiers in nature-based tourism. *Scandinavian Journal of Hospitality and Tourism*, 10(3), 177-189.
- FUSIONS EU. (2016). Estimates of European food waste levels (ISBN 978-91-88319-01-2). European Commission. Retrieved March 13, 2023, from <http://www.fusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf>
- Getz, D. (2007). *Event studies: theory, research and policy for planned events*. Elsevier.
- Getz, D. (2008). Event tourism: Definition, evolution, and research. *Tourism Management*, 29(3), 403-428.
- Getz, D. (2012). Event studies. In: S. J. Page; J. Connell (eds.), *The Routledge handbook of events* (27-46). Routledge.
- Getz, D. (2017). Developing a framework for sustainable event cities. *Event Management*, 21(5), 575-591.
- Getz, D.; Page, S. J. (2015). Progress and prospects for event tourism research. *Tourism Management*, 52, 593-631.
- Getz, D.; Page, S. J. (2020) *Event Studies: Theory research and policy for planned events*. Routledge.
- Gibson, C., & Connell, J. (2012). *Music festivals and regional development in Australia*. Ashgate Publishing, Ltd..
- Gibson, C., & Wong, C. (2011). Greening rural festivals: Ecology, sustainability and human-nature relations. *Festival places: revit Analysis, Behaviour and Strategy*, 318-338.
- Gibson, C.; Davidson, D. (2004). Tamworth, Australia's 'country music capital': place marketing, rurality, and resident reactions. *Journal of Rural Studies*, 20(4), 387-404.
- Gibson, H. (2005). Sport tourism: Concepts and theories. An introduction. *Sport in Society*, 8(2), 133–141.
- Gill, J. A., Norris, K., & Sutherland, W. J. (2001). Why behavioural responses may not reflect the population consequences of human disturbance. *Biological Conservation*, 97(2), 265–268.
- Goedt, U., & Alder, J. (2001). Sustainable Mountain Biking: A Case Study from the Southwest of Western Australia. *Journal of Sustainable Tourism*, 9(3), 193–211.
- Goldblatt, J. (2010). *Special events: A new generation and the next frontier* (Vol. 13). John Wiley & Sons.
- Goldblatt, J. (2013). *Special events: creating and sustaining a new world for celebration*. Wiley Global Education.
- Goldblatt, S. D. (2011). *The complete guide to greener meetings and events* (Vol. 61). John Wiley & Sons.

- Gössling, S., Hansson, C. B., Hörstmeier, O., & Saggel, S. (2002). Ecological footprint analysis as a tool to assess tourism sustainability. *Ecological economics*, 43(2-3), 199-211.
- Greene, D. L., & Wegener, M. (1997). Sustainable transport. *Journal of Transport Geography*, 5(3), 177-190.
- Greentime. (n.d.). O-Ringen Uppsala 2022. Retrieved April 20, 2023, from <https://greentime.se/app/evenemang/?s=4fb533ccb6594ea0436a031d372b8aa31e751bdf3467fd2bef5c3bb031ad2ad7>
- Hall, C. M. (2019). Constructing sustainable tourism development: The 2030 agenda and the managerial ecology of sustainable tourism. *Journal of Sustainable Tourism*, 27(7), 1044-1060.
- Hall, C. M., & Sharples, L. (2008). Food and wine festivals and events around the world: Development, management and markets. Routledge.
- Hall, C. M.; Page, S. (2012). Geography and the study of events. In: S. J. Page; J. Connell (eds.), *The Routledge handbook of events*, 148-164. Routledge.
- Hanrahan, J., & Maguire, K. (2015). Local authority provision of environmental planning guidelines for event management in Ireland. *European Journal of Tourism Research*, 12, 54-81
- Harvard T.H. Chan School of Public Health. (n.d.). Fossil Fuels & Health. Harvard T.H. Chan School of Public Health | C-CHANGE. Retrieved March 27, 2023, from <https://www.hsph.harvard.edu/c-change/subtopics/fossil-fuels-health/#:~:text=Producing%20and%20burning%20fossil%20fuels,coal%2C%20oil%20and%20natural%20gas.>
- Hawkins, J., & Weintraub, M. N. (2011). The Effect of Trails on Soil in the Oak Openings of Northwest Ohio. *Natural Areas Journal*, 31(4), 391-399.
- Hayes, G., & Karamichas, J. (Eds.). (2011). *Olympic Games, mega-events and civil societies: Globalization, environment, resistance*. Springer.
- Heberlein, T. A. (2012) *Navigating environmental attitudes*. Oxford university press.
- Higham, J. (1999). Commentary-sport as an avenue of tourism development: An analysis of the positive and negative impacts of sport tourism. *Current Issues in Tourism*, 2(1), 82-90.
- Hogg, D., & Ingwersen, F. (2012). Environmental Impact of an Orienteering Event on Eucalypt Forest and Woodland in Australia in Relation to Competitor Numbers. Vol. September, 1-14.
- Holmes, K., & Mair, J. (2020). Event impacts and environmental sustainability. In S. Page, J. Connell (eds.) *The Routledge Handbook of Events* (pp. 457-471). Routledge.
- Huddart, D. (2019). Geocaching, Letterboxing, and Orienteering. *Outdoor Recreation*, 249-265.
- International Olympic Committee [IOC]. (1997). *Manual on Sport and the Environment*. International Olympic Committee. Retrieved February 22, 2023, from <https://stillmed.olympic.org/media/Document%20Library/OlympicOrg/IOC/Who-We-Are/Commissions/Sustainability-And-Legacy-Commission/EN-Manuel-Sport-Environment.pdf>
- IOF. (2002). *World Orienteering Championships 2001 Tampere, Finland Environmental Audit Report*. World Wide Fund for Nature, Finland Finnish Environmental Institute International Orienteering Federation. Finland
- IOF. (2023). *Orieentering and the Environment - IOF Survey*. <https://orienteering.sport/iof/environment-and-sustainability/>
- IOF. (n.d.). History and archives |. International Orienteering Federation. Retrieved April 14, 2023, from [https://orienteering.sport/iof/history-and-archives/#:~:text=The%20International%20Orienteering%20Federation%20\(IOF,Norway%2C%20Sweden%2C%20and%20Switzerland.](https://orienteering.sport/iof/history-and-archives/#:~:text=The%20International%20Orienteering%20Federation%20(IOF,Norway%2C%20Sweden%2C%20and%20Switzerland.)
- Isniah, S., Purba, H. H., & Debora, F. (2020). Plan do check action (PDCA) method: literature review and research issues. *Jurnal Sistem dan Manajemen Industri*, 4(1), 72-81.

- Jeppesen, J. L. (1984). Human disturbance of roe deer and red deer: preliminary results. In *Multiple-use Forestry in the Scandinavian Countries. Proceedings of the Symposium Held in Rovaniemi and Saariselkä, Finland, 13-17 Sept. 1982*, 120, 113–118.
- Johnson, C. N. (2002). The benefits to PDCA. *Quality Progress*, 35(5), 120.
- Kaplanidou, K.; Gibson, H. J. (2010). Predicting behavioural intentions of active event sport tourists: The case of a small-scale recurring sports event. *Journal of Sport & Tourism*, 15(2), 163–179.
- Kotze, N. (2006). Cape Town and the Two Oceans Marathon: The impact of sport tourism. *Urban forum* 17(3), 282–293.
- Lenzen, M., Sun, Y. Y., Faturay, F., Ting, Y. P., Geschke, A., & Malik, A. (2018). The carbon footprint of global tourism. *Nature climate change*, 8(6), 522–528.
- Leung, Y. F.; Marion, J. L. (1999). Spatial strategies for managing visitor impacts. *Journal of Park and Recreation Administration*, 17(4), 20–38.
- Liddle, M. (1997). *Recreation Ecology: The Ecological Impact of Outdoor Recreation (Conservation Biology (Hardcover))* (1997th ed.). Chapman & Hall.
- Lienhard, P., & Preuss, H. (2014). Legacy, sustainability and CSR at mega sport events: An analysis of the UEFA EURO 2008 in Switzerland. Springer.
- Lienhard, P., & Preuss, H. (2014). Legacy, sustainability and CSR at mega sport events: An analysis of the UEFA EURO 2008 in Switzerland. Springer.
- Madsen, J., & Fox, A. D. (1995). Impacts of hunting disturbance on waterbirds - a review. *Wildlife Biology*, 1(4), 193–207.
- Mair, J. (Ed.). (2018). *The Routledge handbook of festivals*. Routledge.
- Mallen, C., & Adams, L. J. (2013). *Sport, recreation and tourism event management: theoretical and practical dimensions*. Routledge.
- Margaryan, L. & Eriksson, A. (2023). 'Invisible' impacts and hybrid spaces of nature-based events : The case of a trail running marathon Fjällmaraton in Sweden. In *Cases for Event Management and Event Tourism*. Goodfellow Publishers.
- Margaryan, L. & Fossgard, K. (2021). Visual staging of nature-based experiencescapes : Perspectives from Norwegian tourism and event sectors. In *Nordic Perspectives on Nature-based Tourism: From place-based resources to value-added experiences*. Edward Elgar. pp. 250–262.
- Margaryan, L. & Fredman, P. (2021a). Working with nature in designing cultural events : The case of Norway. I *Managing Visitor Experiences in Nature-based Tourism*. CABI Publishing.
- Margaryan, L., & Fredman, P. (2021). Fantastic, magical and grandiose: nature's role in event design. In Fredman & Jan Vidar Haukeland (eds.) *Nordic perspectives on nature-based tourism*. Edward Elgar Publishing.
- Mendoza, A. (2002). Assessing the Impacts of an Orienteering Competition at Bow Valley Wildland Park. Alberta, Canada from.
- Marion, J. L., Leung, Y., Eagleston, H., & Burroughs, K. (2016). A Review and Synthesis of Recreation Ecology Research Findings on Visitor Impacts to Wilderness and Protected Natural Areas. *Journal of Forestry*, 114(3), 352–362.
- Mascarenhas, M., Pereira, E., Rosado, A., & Martins, R. (2021). How has science highlighted sports tourism in recent investigation on sports' environmental sustainability? A systematic review. *Journal of Sport & Tourism*, 25(1), 42–65.
- McCoy, K., Oliver, J. J., Borden, D. S., & Cohn, S. I. (2018). Nudging waste diversion at Western State Colorado University: Application of behavioral insights. *International Journal of Sustainability in Higher Education*, 19(3), 608–621.
- McCullough, B. P., Bergsgard, N. A., Collins, A., Muhar, A., & Tyrväinen, L. (2018). The Impact of Sport and Outdoor Recreation (Friluftsliv) on the Natural Environment. MISTRA.
- MeetGreen. (n.d.). Infographics. Retrieved March 28, 2023, from <https://meetgreen.com/event-resources/infographics/>

- Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. *Science advances*, 2(2), e1500323.
- Mikayilov, J. I., Mukhtarov, S., Mammadov, J., & Azizov, M. (2019). Re-evaluating the environmental impacts of tourism: does EKC exist? *Environmental Science and Pollution Research*, 26(19), 19389–19402.
- Minx, J. C., Wiedmann, T., Wood, R., Peters, G. P., Lenzen, M., Owen, A., ... & Ackerman, F. (2009). Input-output analysis and carbon footprinting: an overview of applications. *Economic systems research*, 21(3), 187-216.
- Müller, C., Townsend, K. A., & Matschullat, J. (2012). Experimental degradation of polymer shopping bags (standard and degradable plastic, and biodegradable) in the gastrointestinal fluids of sea turtles. *Science of the Total Environment*, 416, 464–467.
- Mykletun, R. J. (2009). Celebration of extreme playfulness: Ekstremsportveko at Voss. *Scandinavian Journal of Hospitality and Tourism*, 9(2-3), 146-176.
- Naidoo, R., & Burton, A. C. (2020). Relative effects of recreational activities on a temperate terrestrial wildlife assemblage. *Conservation Science and Practice*, 2(10).
<https://doi.org/10.1111/csp2.271>
- Naturvårdsverket. (n.d.). Orientering. Retrieved February 22, 2023, from
<https://www.naturvardsverket.se/amnesomraden/allemansratten/aktiviteter/orientering/>
- Naturvårdsverket. (2022). Arrangemang i naturen.
<https://www.naturvardsverket.se/4a301f/globalassets/media/publikationer-pdf/8800/978-91-620-8894-1.pdf>
- Nordvall, A.; Pettersson, R.; Svensson, B.; Brown, S. (2014). Designing events for social interaction. *Event Management*, 18(2), 127-140.
- Notter, D. A., Gauch, M., Widmer, R., Wager, P., Stamp, A., Zah, R., & Althaus, H. J. (2010). Contribution of Li-ion batteries to the environmental impact of electric vehicles.
- O'Brien, D.; Chalip, L. (2007) Sport events and strategic leveraging: Pushing towards the triple bottom line. *Tourism Management: Analysis, Behaviour and Strategy*, 318-338.
- OECD. (1996). Towards sustainable transportation. OECD Proceedings of the Vancouver Conference. Organization of Economic Cooperation and Development.
- Orienteering Ireland. (n.d.). Orienteering Maps – explanation. Orienteering in Ireland - Official Website of Orienteering Ireland. Retrieved April 14, 2023, from
<https://www.orienteering.ie/orienteering-maps-explanation/>
- Orienteering USA. (n.d.). What is Orienteering - Orienteering USA. Retrieved April 14, 2023, from
<https://orienteeringusa.org/explore/what-is-orienteering/>
- O-Ringen AB. (2020) STRATEGI O-RINGEN 2021–2025. Oringen.se
- O-Ringen AB. (2021). Årsredovisning 2022. Oringen.se
- O-Ringen AB. (2022). O-Ringen Magazin Nr. 2 2022.
- Ortolano, L., & Shepherd, A. (1995). Environmental impact assessment: challenges and opportunities. *Impact assessment*, 13(1), 3-30.
- Page, S. (2005). Transport and tourism: Global perspectives. Pearson education.
- Page, S. J., & Connell, J. (2020). *Tourism* (5th ed.) [Ebook]. Routledge.
- Page, S. J., & Connell, J. (Eds.). (2014). *The Routledge handbook of events*. Routledge.
- Parker, B. (2010). Orienteering a nature sport with low ecological impact. Environment commission
- Parker, B. H. (2005). Review of research into the ecological impact of orienteering. In British Orienteering Federation. International Orienteering Federation. Retrieved February 15, 2023, from https://www.britishorienteering.org.uk/images/uploaded/downloads/organisers_ecologicalimpactoforienteering.pdf
- Patterson, I.; Getz, D. (2013). At the nexus of leisure and event studies. *Event Management*, 17(3), 227-240.

- Pereira, R. P. T., Camara, M. V. O., Ribeiro, G. M., & Filimonau, V. (2017). Applying the facility location problem model for selection of more climate benign mega sporting event hosts: A case of the FIFA World Cups. *Journal of Cleaner Production*, 159, 147-157.
- Pröbstl-Haider, U., Lund-Durlacher, D., Antonschmidt, H., & Hödl, C. (2017). Mountain bike tourism in Austria and the Alpine region – towards a sustainable model for multi-stakeholder product development. *Journal of Sustainable Tourism*, 26(4), 567–582.
- Quinn, N. W., Morgan, R. P. C., & Smith, A. J. (1980). Simulation of soil erosion induced by human trampling. *Journal of Environmental Management*, 10(2), 155–165.
- Rajan, J., & Booth, A. L. (2016). Sustainability and waste management of the 2015 prince George Canada winter games. *International Journal of Sustainable Development and Planning*.
- Razza, F., Fieschi, M., Innocenti, F. D., & Bastioli, C. (2009). Compostable cutlery and waste management: An LCA approach. *Waste Management*, 29(4), 1424–1433.
- Rodrigue, J. P. (2020). *The geography of transport systems*. Routledge.
- Ruhanen, L., McLennan, C., & Moyle, B. D. (2019). New directions in sustainable tourism research. *Tourism Review*, 74(2), 138–149.
- Rutty, M., Scott, D., Steiger, R., & Johnson, P. (2015). Weather risk management at the Olympic Winter Games. *Current Issues in Tourism*, 18(10), 931-946.
- Salazar, N. B., Timmerman, C., Wets, J., Gato, L. G., & Van den Broucke, S. (Eds.). (2016). *Mega-event mobilities: A critical analysis*. Taylor & Francis.
- Salesa, D., & Cerdà, A. (2019). Four-year soil erosion rates in a running-mountain trail in eastern Iberian Peninsula. *Cuadernos De Investigación Geográfica*, 45(1), 309–331.
- Scrucca, F., Severi, C., Galvan, N., & Brunori, A. (2016). A new method to assess the sustainability performance of events: Application to the 2014 World Orienteering Championship. *Environmental Impact Assessment Review*, 56, 1-11.
- Shiklomanov, I. A. (1991). The world's water resources. In *Proceedings of the international symposium to commemorate* (Vol. 25, pp. 93-126). Paris, France: Unesco.
- Smith, A., Robbins, D., & Dickinson, J. E. (2019). Defining sustainable transport in rural tourism: Experiences from the New Forest. *Journal of Sustainable Tourism*, 27(2), 258-275.
- Straupe, I., & Ivbulė, I. (2022). Impact of Orienteering Competitions On Ground Vegetation In Pine Forests At The Seaside, Latvia. *Rural Development*, 2021(1), 285–289.
- Sutherland, W. J. (1996). *From Individual Behaviour to Population Ecology*. Oxford University Press.
- Svenska Orienteringsförbundet. (1996). *Mark och vilt.Handledning i mark och viltfrågor i samband med kartritning och orienteringsarrangemang*.
- Svenska Orienteringsförbundet. (2015). *Viltvänlig banläggning*
- Svenska Orienteringsförbundet. (2015a). *Naturhänsyn – Kontrollval*.
- Svenska Orienteringsförbundet. (2019). *Arrangera klimatsmart*.
- Svenska Orienteringsförbundet. (2021a). *Fakta och statistik från 2021*.
- Svenska Orienteringsförbundet. (2021b). *Svensk orientering 2021*.
- Svenska Orienteringsförbundet. (n.d.). *Natur och miljöprogram*.
- Svenska Orienteringsförbundet. (n.d.a). *Verksamhetsplan 2023-2024 för Svenska Orienteringsförbundet*
- Svenska Orienteringsförbundet. (n.d.b). *Hallbarhetspolicy: Svensk Orientering*.
- Svenska Orienteringsförbundet. (n.d.c). *Strategi – Kompassriktning 2030*.
- Taks, M. (2013). Social sustainability of non-mega sport events in a global world. *European Journal for Sport and Society*, 10(2), 121-141.
- Thurston, E., & Reader, R. J. (2001). Impacts of Experimentally Applied Mountain Biking and Hiking on Vegetation and Soil of a Deciduous Forest. *Environmental Management*, 27(3), 397–409.
- Trail, G. T., & McCullough, B. P. (2021). A longitudinal study of sustainability attitudes, intentions, and behaviors. *Sustainability Science*, 16, 1503-1518.

- Trail, G., & Mccullough, B. P. (2018). Differential Effects of Internal and External Constraints on Sustainability Intentions: a Hierarchical Regression Analysis of Running Event Participants by Market Segment. *Journal of Management for Global Sustainability*, 6(2).
- Trendafilova, S. (2011). Sport subcultures and their potential for addressing environmental problems: the illustrative case of disc golf. *The Cyber Journal of Applied Leisure and Recreation Research*, 13(1), 1–14.
- Triantafyllidis, S., Ries, R. J., & Kaplanidou, K. (2018). Carbon dioxide emissions of spectators' transportation in collegiate sporting events: Comparing on-campus and off-campus stadium locations. *Sustainability*, 10(1), 241.
- United Nations. (1987). *Our Common Future-Brundtland Report*, A/42/427; United Nations.
- United Nations. (2022). *The Sustainable Development Goals Report 2022*.
<https://unstats.un.org/sdgs/report/2022/>
- United Nations. (n.d.). *SDG 6 – Targets and indicators*. UN- Department of Economic and Social Affairs. Retrieved March 29, 2023, from <https://sdgs.un.org/goals/goal6>
- University of London. (n.d.). *How to run more sustainable events*. Venue Hire in London. Retrieved March 27, 2023, from <https://www.london.ac.uk/venues/blog/how-run-more-sustainable-events>
- UNWTO & ITF. (2019). *Transport-related CO2 Emissions of the Tourism Sector – Modelling Results*
- UNWTO & UNEP (2008). *Climate change and tourism – responding to global challenges*, UNWTO, madrid, DOI: <https://doi.org/10.18111/9789284412341>.
- Upplevelseinstitutet. (2022). *Turistekonomisk rapport O-Ringen 2022*, uppsala.
<https://press.destinationuppsala.se/media/204957/turistekonomisk-rapport-or22>
- Vallström, M. (ed.) (2014). *När verkligheten inte stämmer med kartan: lokala förutsättningar för hållbar utveckling*. Nordic Academic Press.
- Wackernagel, M., & Rees, W. (1998). *Our ecological footprint: reducing human impact on the earth* (Vol. 9). New society publishers.
- Wackernagel, M., Lin, D., Hanscom, L., Galli, A., & Iha, K. (2019). *Ecological Footprint*. Elsevier eBooks, 270–282.
- Wallstam, M., Ioannides, D., & Pettersson, R. (2020). Evaluating the social impacts of events: In search of unified indicators for effective policymaking. *Journal of Policy Research in Tourism, Leisure and Events*, 12(2), 122-141.
- Wanger, T. C. (2011). The Lithium future—resources, recycling, and the environment. *Conservation Letters*, 4(3), 202-206.
- Weaver, D. B. (2006). *Sustainable Tourism: Theory and Practice*. Routledge.
- Weed, M. (2012). An interdisciplinary event research agenda across sport, tourism, leisure and health. In: S. J. Page; J. Connell (eds.), *The Routledge handbook of events*, 57-71. Routledge.
- Westerbeek, H., Smith, A., Turner, P., Emery, P., Green, C., & Van Leeuwen, L. (2005). *Managing sport facilities and major events*. Allen & Unwin.
- Wolf, I. D., Croft, D. B., & Green, R. J. (2019). Nature Conservation and Nature-Based Tourism: A Paradox? *Environments*, 6(9), 104.
- World Wildlife Fund [WWF]. (n.d.). *What is Erosion? Effects of Soil Erosion and Land Degradation*. World Wildlife Fund. Retrieved February 23, 2023, from <https://www.worldwildlife.org/threats/soil-erosion-and-degradation>
- Ziakas, V.; Costa, C. (2011). Event portfolio and multi-purpose development: Establishing the conceptual grounds. *Sport Management Review* 40, 409-423.

