Interreg CENTRAL EUROPE

Co-funded by the European Union

HUMANITA

Lilia Schmalzl; Zuzanna Kieliszek

Report on **good-practice examples** to monitor environmental impacts of tourism inside protected areas

Brief summary / Abstract

Within the **INTERREG CE Project HUMANITA,** we are looking for insights from good-practice owners from PAs and scientific institutions around the world into the monitoring of environmental impacts of tourism inside PAs. This report gives an overview of good-practice examples of monitoring visitors / tourists and their environmental impacts inside protected areas (PAs) that were identified by the project consortium. Regarding environmental impacts, it highlights good-practice impact assessment **for wildlife monitoring, vegetation monitoring, erosion monitoring and pollution monitoring.** It is the result of joint desk research and knowledge-exchange of eleven Central European project partners. The very diverse partnership of practitioners and research institutions in the **HUMANITA project** consortium guarantees a broad expertise and experience in different fields of monitoring. This includes traditional as well as technology-based monitoring methods.

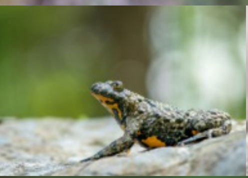
The desk research on good-practice examples focuses on methods that can support the monitoring of existing environmental impacts related to tourism at project pilot sites. The main aim of the **HUMANITA project** is to develop **six solutions to monitor environmental impacts of tourism.** These include the following study focuses: **1)** visitor monitoring, **2)** wildlife monitoring, **3)** vegetation monitoring, **4)** erosion monitoring, and **5)** pollution monitoring; while the **sixth** solution includes the implementation of a Citizen Science project that will be elaborated during the next stage of the project.

The report gives a general introduction on tourism in protected areas and related environmental impacts. It is followed by a description of activities carried out to determine good-practice examples for monitoring these impacts.

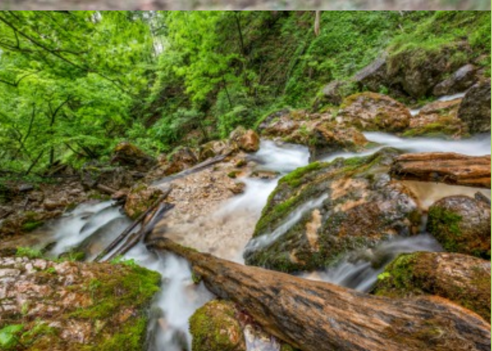
The following chapters give an overview on the topics of **visitor monitoring, wildlife monitoring, vegetation monitoring, erosion monitoring, and pollution monitoring.** Four of five study focuses were addressed in the workshop with good-practice owners. A summary of their presentation is provided in the report to showcase examples of good-practice. Good-practice examples on the **6th solution** on implementation of **Citizen Science** projects will be included in the report on participatory monitoring in PAs **(D.3.2.3).**

A shared online list of good-practice examples is being compiled by all project partners. The list is organized in a database structure to easily filter examples or search for a specific study focus or technology use. The list serves as a working document for project partners. Further examples may be collected during the whole project duration. In this way, project partners create a shared knowledge space.

The list of good-practice examples was converted to a series of **factsheets.** These are included in **chapter 3** of this report. They give a compact and comprehensive overview



of the identified monitoring approaches. You may experience many of the approaches portraited in the factsheets are still in an experimental phase. This is because we mostly illustrate relatively new, innovative, primarily technology-based approaches in this report. Partners identified these example as good-practice because they offer a high potential for further development. A summary of methods, results and existing gaps is provided for each example. References are included for further reading.

This collection of good-practice examples to monitor visitors and their environmental impacts on the environment and all activities leading to this report serve as a starting point for the monitoring strategy and action plan for project partners of **HUMANITA.** We are proud to share our knowledge base within this report and hope that it will provide inspiration for PA managers of Central Europe and beyond on monitoring methods to implement and measure environmental impacts of tourism within their region.

The project **HUMANITA** is supported by the Interreg CENTRAL EUROPE Programme 2021-2027 with co-financing from the European Regional Development Fund. It brings together **11 partners** from Austria/Slovenia, Croatia, Hungary, Italy and Slovakia. Scientists are working together to develop and test innovative solutions to assess the impact of tourist activities on nature, with the objective to assist managers of PAs to safeguard the environment. Participatory monitoring involving individuals from local communities and tourist groups will deliver a new 'common heritage' narrative, laying the groundwork for transformative change and supporting positive human-nature relationships. Project outputs will help PA managers put the right measures in the right places, make smarter decisions, prevent negative impacts, mitigate human-nature conflicts and reduce risks.

Impressum

Project title:
HUMANITA – Human-Nature Interactions and Impacts of Tourist Activities on Protected Areas

Project Lead:
Dana Sitányiová; University of Žilina

Authors:
Lilia Schmalzl; Zuzanna Kieliszek; Carinthia University of Applied Sciences

Reviewers:
Isidoro De Bortoli; Dana Sitányiová; Alessandro Valletta; Daniel Dalton

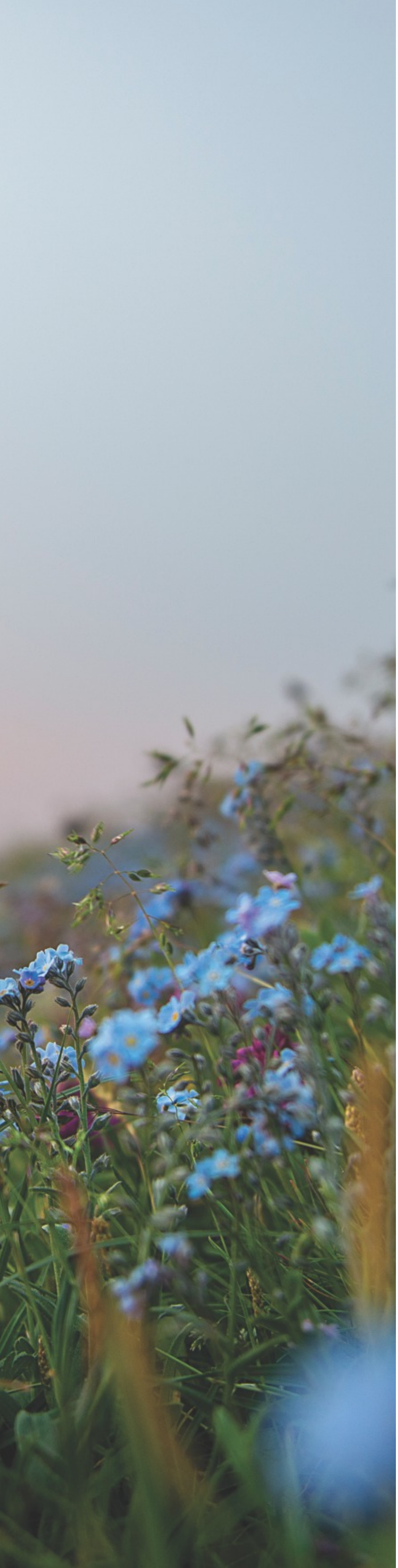
Factsheets of Good-Practice:
Jozef Limánek; Michal Kalaš; Ádám Varga; Linda Magyar; Lilia Schmalzl; Zuzanna Kieliszek; Danijela Modrej; Urosh Grabner; Dana Sitányiová; Balázs Megyeri; Filippo Favilli; Maja Pamić; Alessandro Valletta

[de]**sign:**
Urosh Grabner; Karawanken–Karavanke **UNESCO** Global Geopark

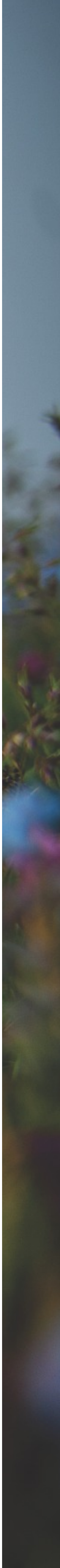
Photos:
Urosh Grabner; Karawanken–Karavanke **UNESCO** Global Geopark

Financing:
INTERREG CE co-funded by the European Union

Proposal for Citation:
Schmalzl, L; Kieliszek, Z. (2023): Report on good-practice examples to monitor environmental impacts of tourism inside protected areas. Carinthia University of Applied Sciences, Villach.



Contents



Impacts of tourism on protected areas

Tourism can be a benefit but also a threat for protected areas (PAs). It can bring economic and social welfare to a region, for example by creating financial renumeration as well as creating jobs. On the other hand, in some PAs overtourism threatens natural and cultural values and may lead to the degradation of landscape and ecosystems. Increasing demand and interest in outdoor activities are great opportunities, but these factors also pose challenges for protected areas to meet visitors' expectations and to protect natural values.

With increased demand for outdoor activities, sustainable tourism management is becoming an essential field of activity for PA management. Monitoring the movement of visitors as well as their impacts on the natural environment is important for PA managers to identify critical hotspots where action is necessary. To support evidence-based and participatory management, a good understanding of the real impacts is necessary to react with an efficient management response.

Within the INTERREG CE Project **HUMANITA,** project partners are looking for insights from good-practice owners from PAs and scientific institutions around the world into the monitoring of environmental impacts of tourism inside PAs. To do so, firstly, all partners contributed good-practice examples to develop a comprehensive joint list. This list is structured in a way that allows the filtering of different good-practice examples. Secondly, a webinar with good-practice owners was organised. A number of good-practice owners were invited to present their methods to the HUMANITA project consortium and further interested parties. **The webinar is publicly available on the project website.** It can be found under the following link on the **YouTube channel** (@Humanita_EU_2023): **www.youtube.com/watch?v=g3p5oHqBSYA**

The report on good-practice to monitor environmental impacts of tourism inside PAs sheds light on promising and innovative approaches to the monitoring of the spatial and temporal behaviour of visitors and explores novel technologies to monitor impacts of visitors on the well-being of our natural environment:

By the integration of automatic visitor counter data with Global Navigation Satellite System-based Volunteered Geographical Information (GNSS VGI) from mobile phone devices, such as outdoor apps or passive mobile data from mobile phone providers, valuable insights into visitor movement patterns can be gained. Furthermore, the proper management of digital data helps to mitigate the potential spread of visitors into sensitive areas.

The report provides insights into the use of modern technologies like acoustic sensors, wildlife cameras and unmanned aerial vehicles (UAVs) in the monitoring of the impacts that tourists may cause when visiting a PA. These advanced tools help us assess the effects of visitors on wildlife, vegetation and soil erosion, ensuring a comprehensive understanding of the human-nature dynamic.

The report refers to the actions taken during **work package 1** in the INTERREG Central Europe Project "**HUMANITA** – Human-Nature Interactions and Impacts of Tourist Activities on Protected Areas".

Advantages and disadvantages of tourism in PAs

PAs cover around 15% of Earth's land. It is estimated that worldwide around **8 billion tourists visit** them annually with expenditures reaching **USD 600 billion.** This demonstrates that PAs are an important contributor for regional development while simultaneously promoting nature conservation. Nevertheless, keeping the balance between conservation and touristic development in PAs is a challenge for PAs managers *(KC, 2022)*. The main obligations of protected areas are the conservation of nature and habitats as well as education. Providing access for visitors is only a side task and not the main obligation. However, the growing demand for recreational activities in PAs has both positive and negative environmental influences. PAs managers face difficult decisions between strengthening conservation of nature and allowing the development of recreational functions. This is the reason why the concept of sustainable tourism rose in popularity in recent years *(Opačić & Koderman, 2020)*. It assumes that environmental, economic and socio-cultural aspects should be in balance to guarantee long lasting sustainability related to visitors *(Candrea & Ispas, 2009)*.

Tourism can bring benefits to PAs. Touristic and recreational activities can contribute to earnings of PAs through the collection of entrance fees or selling of books, maps and other promotional materials *(Oviedo-García et al., 2019)*. Furthermore, tourists visit PAs because they want to understand and admire the values to conserve the natural environment. PAs can also be the impulse to raise awareness among visitors, especially thanks to educational activities. As a result, tourists can become more conscious about the importance of the environment for humans and the whole planet. Moreover, it is likely that rising numbers of visitors might strengthen the economy of local communities, improve socio-cultural life, decrease poverty in the region, increase the numbers of new jobs and promote conservation *(Štrba et al., 2022)*.

Tourism can also cause problems in PAs. It can have a negative impact on the environment, society and the economy. Changes of land cover and land use, pollution, urbanization and acquisition of land by new actors are thought to be one of the most important drawbacks of tourism *(Canteiro et al., 2018)*. Recreation and tourism activities can have a significant influence on vegetation, wildlife and geodiversity. One example is clearing vegetation in order to provide visitor infrastructure like trails, roads or lodges. Moreover, the use of such facilities can cause changes in hydrology and soil erosion. Of course, factors like the number of visitors, the type of their activity and their behaviour in nature influence the scale of tourism impacts on the environment *(Pickering & Hill, 2007)*.

This report emphasises **research** during the **HUMANITA project** on the **monitoring of five different study focuses: visitor monitoring, wildlife monitoring, vegetation monitoring, erosion monitoring,** and **pollution monitoring.** Chapters are dedicated to each topic including information on good-practice examples gained through desk research and workshop activities. The first focus is on visitor monitoring and management. It sheds light on state-of-the-art technologies that enable visitor monitoring in protected areas. This chapter gives an overview of advantages and disadvantages of classic and modern monitoring methods. The report focuses next on wildlife monitoring. Good-practices measuring human disturbance on animals are included in this section. The featured examples demonstrate use of devices like wildlife cameras and acoustic sensors. Third, the report puts attention on vegetation monitoring. It describes the process of trampling and the methods to measure it in the mountainous areas. The fourth topic is erosion monitoring as shown in good-practice examples describing the latest monitoring technologies. The subject of pollution is covered, with the focus on plastic pollution in coastal areas. **To sum up the results of the list of good practice examples, short factsheets are included in chapter 4.**

1. Collection of good-practice examples to monitor visitors and their environmental impacts on protected areas

To develop a **transnational monitoring strategy** to monitor the impacts of tourism on the environment, the **HUMANITA project** consortium aims to build upon the experiences of good-practice owners from around the world. In regard to the environmental impacts of tourism, PAs around the world face similar challenges. Pressures become obvious when visitor numbers reach or exceed the carrying capacities of an area. An exchange with researchers, practitioners and entrepreneurs from around the globe on how to monitor these pressing challenges will support the quality of monitoring activities within the **HUMANITA project.**

This report outlines the project activities that led to the identification of good-practice examples. Every project partner started with a desk research task on the most promising, innovative, technology-based monitoring methods. Each partner placed their study focus on the monitoring requirements that are of interest for the management of visitors at their pilot sites. **This resulted in the definition of five main monitoring subjects:** visitor monitoring & management, wildlife monitoring, vegetation monitoring, erosion monitoring and pollution monitoring.

In a workshop, **eight good-practice owners** were invited to present their activities in the field of visitor monitoring, wildlife monitoring, trampling and erosion monitoring. A webinar was recorded and can be publicly accessed following the link on the **YouTube channel** (@Humanita_EU_2023):
www.youtube.com/watch?v=g3p5oHqBSYA

In the **following chapters** the collection of good-practice examples and the results of the workshop will be outlined:

1.1. Elaboration of a list of good-practice examples

A list of good-practice examples to monitor environmental impacts of visitors in PAs was established. The study focuses of desk research were invested in monitoring efforts that pose a challenge for sustainable tourism management within the pilot sites of the **HUMANITA** project.

Scientific articles and project reports focusing on the monitoring of visitors and their impacts on the environment were included in the list. A prerequisite for inclusion of good-practice examples was that the methodology had to have already been successfully implemented inside a PA. Furthermore, technology and data providers offering market-ready tools for visitor monitoring were collected. Additionally, useful web applications and dashboards for visitor monitoring and management were identified.

The list is a working document for the project consortium and is organized in an excel file. In this way, it allows easy filtering according to details of the monitoring, details on the monitoring sites or the type of institution involved. The list will be continued throughout the whole project duration and will serve as a joint good-practice knowledge base.

For the purposes of documentation and dissemination of the list, the information on good-practice examples was compiled in a collection of factsheets **(Chapter 4).** In it, the identified good-practice examples are sorted in relation to their main study focus.

In the **following figures** the structure of the list is explained in more detail (**Figure 1 & Figure 2**). The descriptions are organized in an online excel spreadsheet that every partner can easily access with a link. The first page provides instructions to the partners on how to work with the list. It also provides a common description of the defined categories. Certain categories are obligatory **(green).** Other categories are optional **(grey).** The list was reviewed by the **project partners** in a two-step process.

Dear Project Consortium,

Welcome to our shared list to collect good-practice examples for the monitoring of visitors and their impacts on the environment in protected areas. Please go to the partner content priorities to define your content priorities for the collection of good-practices.

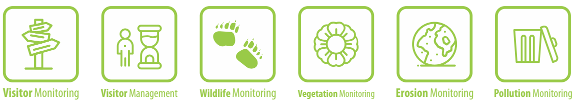
We defined categories that can be used to filter the good-practice examples listed. Please take your time to go through the description of the categories below and look at the examples provided in the list of good-practice, before filling in your good-practice examples.

Please, **pay attention** to the columns which are marked in **green color,** they are **required to fill in.**
Grey color columns **are optional** and are to be filled in only if the information is available.
If you choose the category option **"other",** please **specify the field** by typing in a description.

Categories description

Monitoring focus	What type(s) of monitoring is/are described?
Type of tool/method	Which tool(s) or method(s) is/are used to carry out the monitoring?
Type of data	Which type of data is generated when monitoring?
Dimension	At what scale is the monitoring taking place?
Transferability to other regions	Is the monitoring method transferable to other regions?
Development level	Is/Are the monitoring method(s) established or still experimental?
Place of monitoring	Where is the monitoring carried out?
Landscape type	What is the landscape type of the place of monitoring?
PA category	What is the protected area category of the site?
Type of organisation	Which kind of organisation is doing the monitoring?
Name of organisation	What is the name of the organisation or first author doing the monitoring?
Country	In which country is the monitoring taking place?
Frequency/interval (smallest)	At which interval is the monitoring carried out? If only once it should be marked as "one time".
Methods	Please describe the methods used.
Results	Please describe the results.
Gaps	Please describe the gaps.
Website of References	Please provide a link to a website or link to the references.
Responsible partner	Please name the partner who described the good-practice.
Contact point from project consortium	Please enter contact information to exchange about this good practice example (this is for internal use only!)
Notes	Please use for further notes that you consider important.

Figure 1: Introduction for good-practice examples collection in Excel spreadsheet and description of categories included in the list of good-practice.



Study focus	Type of tool/method	Type of data	Dimensions	Transferability to other regions	Development level
Visitor monitoring	Device	Spatial data	Local	Yes ✓	Established
Visitor management	App	Alphanumerical data	Regional	No ✗	Experimental
Wildlife monitoring	Other software	Optical data	National		
Vegetation monitoring	Remote sensing	Acoustic data	International		
Erosion monitoring	Survey/interview				
Pollution monitoring	Literature review				
	Other				

Landscape type	Protected Area Category	Type of organization	Frequency/interval (smallest)
Bog	National Park	Park management	One-time
Forest	Biosphere reserve	Service provider	Continuous
Grassland	Nature Park	Research company	Weekly
Lake	Nature reserve	Association	Monthly
Sea	Geopark	Other	Yearly
River	Landscape protection area		More than one year
Glacier	Natura 2000		No information
Rock	Other		
Beach	Unrelated		
Unrelated			

Figure 2 Categories with predefined attributes that can be filtered to search for appropriate monitoring methods.
The list allows the selection of different study focuses, such as visitor monitoring, wildlife monitoring, vegetation monitoring or erosion monitoring. Furthermore, the type of tool used (i.e. device, app, other software, remote sensing, etc.) and the type of data generated (i.e. spatial data, optical data, acoustic data) can be selected. Also, information about the type of organization performing the monitoring can be included in the list. For each good-practice example, a description of the methods used, the results generated as well as the gaps identified is included. This allows the user to get an overview of the advantages and disadvantages of the described monitoring approach. You can find a factsheet of each good-practice example that was included in the list in **chapter 3** of the report.

1.2. Conduction of a webinar with good-practice owners

A good-practice webinar was conducted in June 2023 to allow all project partners as well as interested parties to gain insights into the practical implementation of different monitoring methods presented directly from a number of invited good-practice owners. The selection of invited good-practice owners was based on **1)** an extensive literature review on good-practice examples, **2)** the network of project partners as well as **3)** the needs of the pilot areas.

The webinar took place on the 29th of June 2023 from 9.00 am – 2.00 pm C.E.T. In the webinar, the INTERREG CE project **HUMANITA** was shortly introduced. In three sessions, good-practice examples for visitor monitoring, wildlife monitoring as well as erosion and trampling monitoring from eight good-practice owners were introduced. A fifteen-minute presentation was followed by a fifteen-minute discussion round for each topic.

Figure 3 gives an overview of the agenda presented in the webinar.

Introduction of aim of the project	9.00 – 9.15	Overview of project objectives
Morning Session	**9.15 – 10.45**	**Visitor monitoring**
Inputs from good-practice owners	9.15 – 10.00	**Potential of GNSS-tracking in visitor monitoring - experiences from recreational areas in Central Europe** Karolina Taczanowska, University of Natural Resources and Life Sciences Vienna (BOKU), Austria
		Visitor monitoring in natural areas Luboš Kala, Partnerství, o.p.s., Czech Republic
		Data platform for digital visitor management in nature Tom Müller, Digitize the planet, Germany
Questions and discussion	10.00 – 10.45	
COFFEE BREAK	10.45 – 11:00	
Mid-day Session	**11.00 – 12.00**	**Monitoring of wildlife**
Inputs from good-practice owners	11.00 – 11.30	**Human activities and wildlife disturbance** Martin Wyttenbach, Zurich University of Applied Sciences
		Impacts of human noise disturbance on wildlife Benjamin Cretois, Norwegian Institute of Nature Research, Norway
Questions and discussion	11.30 – 12.00	
LUNCHBREAK	12.00 – 12:30	
Afternoon Session	**12.30 – 14.00**	**Erosion and Trampling Monitoring**
Inputs from good-practice owners	12.30 – 13.15	**Impact on vegetation - Assessment of Hyperspectral Remote Sensing for Analyzing the Impact of Human Trampling** Marlena Kycko, University of Warsaw, Poland
		Geomatics Techniques for Erosion Monitoring on Mountain Trails Riccardo Roncella, University of Parma, Italy
		Assessment of the Possibility of Using (UAVs) for the Documentation of Hiking Trails in Alpine Areas Paweł Ćwiąkała, AGH University of Science and Technology Kraków, Poland
Questions and discussion	13.15 – 14.00	

Figure 3 Good-practice workshop agenda and presenters whose good-practices are described in **chapter 2.**



2. Good-practice for monitoring visitors and their environmental impacts inside protected areas

This chapter primarily revolves around proposed good-practices shared during the workshop and gathered by project partners as part of desk research. Additionally, it delves into the study focuses addressed in the INTERREG Central Europe project **HUMANITA.**

The structure of this section of the report is organized into subchapters, with each focus presented as a subsection. Each subsection includes a brief description of the study focus and available methods, as documented in scientific journals. Furthermore, it offers insights into the good-practice examples presented during the **HUMANITA** workshop, completed with presenter affiliations and references to their publications.

Visitor Monitoring: The first area of interest revolves around monitoring visitors of PAs. Various approaches are presented, with the advent of progressive technology enabling a shift from conventional to more contemporary monitoring methods. The chapter showcases how data collection can extend beyond fieldwork and surveys, encompassing GPS data and information provided by users through outdoor applications.

Wildlife Monitoring: This subsection focuses on interactions between humans and wildlife. Two approaches of utilizing modern devices are explored: GPS trackers and acoustic sensors. These methods shed light on the impact of PA visitors' activities on wildlife.

Vegetation Monitoring: This subsection delves into the influence of visitors on flora, particularly in proximity to trails. A notable example illustrates the use of remote sensing to monitor vegetation status, cross-referencing it with spectrometer-acquired data.

Erosion Monitoring: Like vegetation monitoring, research on erosion monitoring investigates human impacts on soils along trails in PAs. It introduces emerging technologies such as photogrammetry and UAVs applicable to such research.

Pollution Monitoring: Although not covered extensively during the good-practice workshop, the **HUMANITA** project emphasizes marine litter monitoring. It provides insights into the selection of sampling locations and proper litter identification, along with an overview on the impact of plastics on sea waters and ecosystems.

2.1. Visitor monitoring and management

Visitor monitoring is an instrument of visitor management that helps manage tourist recreation destinations *(Mason, 2005)*. To understand tourism impacts on the environment it is critical to have an overview of the spatial and temporal movement of visitors *(Leung et al., 2018)*. Muhar et al. *(2002)* give a systematic overview of traditional methods that are used for visitor monitoring in recreational areas and PAs. These include direct observations, video observations, the use of counting devices and numbers from indirect data. Indirect data sources include registration books, cable car tickets, entry fees and others. In recent years the portfolio of data that can be used to understand the movement of visitor within PAs has significantly increased. One possibility is the use GPS loggers, which can be distributed among tourists to better understand spatially unconstrained outdoor activities, for example ski touring *(Bielański et al., 2018)*. Another possibility is the use of Global Navigation Satellite System-based Volunteered Geographical Information (GNSS VGI data). In this case, data from various outdoor and fitness tracker apps is used to analyse visitor movement. Data are provided in GPX file format, containing movement trajectories of visitors that share their routes via the outdoor platforms. Using this information, high- or low-use routes can be identified in PAs. Still, the data will not deliver exact information on visitor numbers at certain points or time periods, like in the case of **visitor counters.** This is due to only limited number of **app users.** Depending on the type of activity and the area of monitoring the data quality highly varies *(Horst et al., 2023)*. Furthermore, the use of **passive mobile data** is becoming more prominent in the field of visitor monitoring. **Mobile network operators** provide such data in an anonymised form, according to national regulations for tourism research. Reif & Schmücker *(2020)* outline the advantages and disadvantages of the use of such data. **Passive mobile data** can measure the mobility of people in space and time, but it is still not suitable for correctly identifying user activities or distinguishing **tourists** from **non-tourists** *(Grassini & Dugheri, 2021)*. Overall, a fusion of various data sources will improve the understanding of visitor movement within PAs.

The analysis of **GNSS VGI data** is an advantage for visitor monitoring. Still, the information provided by outdoor apps can become a threat for protected areas and a safety risk of visitors. Growing popularity of outdoor applications for mobile devices, like **Outdooractive, Trailforks** or **STRAVA** can increase the impact of tourists on the environment, as they often include unofficial trails in their maps. Information displayed in outdoor apps is usually based on crowdsourced data like **OpenStreetMap.** Such geodata are usually not verified by local authorities or PA management. This may lead to situations where visitors navigate along unofficial trails inside sensitive areas, without even being aware of it. Unverified geodata may even provoke dangerous situations for the visitor, as the difficulty of such trails might not be addressed properly in the description.

To **better understand** the above-mentioned **methodologies** and **management practices,** we invited **three good-practice** owners to our online workshop to share their experiences in the field of visitor monitoring. In the following we present a summary of the use of **GNSS VGI data,** introduced by Karolina Taczanowska, University of Natural Resources and Life Sciences (BOKU). Luboš Kala from Partnerstvi o.p.s presents the application of **automatic visitor counters** to measure the frequency of visitors alongside trails. Furthermore, Tom Müller from **Digitize the Planet** sheds light on the idea of how the association works towards the integration of information about nature protection to outdoor apps. This will enable visitors to make informed decisions when planning their routes with outdoor apps.

2.1.1. Potential of GNSS tracking in visitor monitoring: experiences from recreational areas in Central Europe, Karolina Taczanowska

Karolina Taczanowska is research professor at the **Institute of Landscape Development, Recreation and Conservation Planning,** at BOKU in Vienna, Austria. Her research focusses on visitor monitoring, more precisely human spatial behaviour within natural areas.

Study focus
Visitor monitoring
Type of tool/method
App/Device: Visitor counter, GPS logger
Type of data
Alphanumerical data, spatial data
Dimensions
Regional
Transferability to other regions ✓
Development level
Experimental

2.1.1.1. Methods

GNSS VGI data allows PA managers to track visitors and their movement during their stay within the region. There are several possibilities to use the data. With an increasing popularity of outdoor apps, many visitors leave their digital traces on the internet. Karolina and her team investigate the advantages and disadvantages of the use of data from **GPSies (currently AllTrails), Outdooractive** and **Komoot.** They analyse the data quality, comparing the information of the apps and the **volumes** of visitor counter data from the area. In another example, **GPS loggers** were used for active tracking of visitors. The devices were distributed amongst the visitors at the PA entrance and then collected at the end of the trip. This method was used for both **summer (hiking)** and **winter (ski touring)** activities *(Taczanowska et al., 2014, 2017)*.

2.1.1.2. Results

The analysis of **GNSS VGI data** from outdoor apps showed positive correlations between investigated platforms and data from the field counts *(Horst et al., 2023)*. The analysis of **GPS logger data** enabled precise determination of spatial coordinates and associated time stamps of tourist activities. Furthermore, the length, time and average speed during the trip could be tracked. With this information heatmaps were generated. These heatmaps serve as visual representations of visitor density and activity within the PA, thereby revealing areas of heightened popularity among tourists and identifying localized hotspots.

2.1.1.3. Gaps

The use of **GNSS VGI data** from **outdoor apps** showed that it is only a **complementary methodology** to understand visitor movement. There are dozens of different outdoor apps available. Therefore, PA managers firstly need to investigate which of them are popular in their regions before integrating the data inside their visitor model. Furthermore, limited numbers of visitors use outdoor platforms to plan, track or share their activities. The data are not representative but can help to understand certain movement patterns. Concerning the use of GPS loggers for active tracking, the data are limited to the number of GPS loggers available and the time frame for handing them out to visitors. Active distribution of the GPS logger could also influence the behaviour of visitors.

2.1.2. Visitor monitoring in natural areas, Luboš Kala

Luboš Kala is a director of **Partnerstvi o.p.s.**, an NGO that has over 15 years of experience in visitor counting and in the use of visitor counters from Eco-Counter and TRAFx. The NGO is closely cooperating with local governments, organizations and conservation areas in Czech Republic.

Study focus	
Visitor monitoring	
Type of tool/method	
Device: Visitor counter	
Type of data	
Alphanumerical data, spatial data	
Dimensions	
Regional	
Transferability to other regions	☑
Development level	
Established	

2.1.2.1. Methods

Many different **automatic visitor counters** are on the market. Depending on the activity type and location, PA managers need to decide which features need to be met. **Infrared counters** or **pressure mats** are used to **monitor walkers, hikers** or **runners.** The beam detects the body heat of passing objects. **Magnetometers** or induction loops are used to **monitor cars** or **bikers.** These detect passing metal objects by measuring the change of electromagnetic fields. The devices are robust and waterproof. When installed above ground, they should be hidden in a wooden post or some kind of box to protect them from vandalism. For the collection of data, some devices need to be connected directly to the dock, so the sensors need to be accessible. Other counters can transmit data via Bluetooth directly to an app or even use the GSM network to send the data to the office. Different dashboard solutions enable to visualize and interpret the visitor counter data for PA managers. The raw data of the counters, stored as a log file, can be used for research.

2.1.2.2. Results

The data gathered from **automatic visitor counters** provides insights into the visitor flow along the paths or trails where the devices are installed. Long-term analysis reveals discernible patterns in visitor behaviour, with factors such as favourable weather, the summer season, special events, and public holidays consistently drawing larger crowds. Additionally, daily patterns and peak visitation times are evident. These data enable in-depth analyses, the results of which can be applied to enhance visitor management strategies for the PA.

2.1.2.3. Gaps

Visitor counting devices have the tendency to either **undercount** or **overcount visitors.** The most significant challenge faced by these devices arises when large groups of tourists pass the installation simultaneously. Consequently, it becomes necessary to expect an error rate when interpreting the results. The choice of the right device and location for visitor counting can significantly reduce the error rates.

2.1.3. Data platform for digital visitor management in nature, Tom Müller

Tom Müller is working in the association **Digitize the Planet.** Founded in Germany in 2020, its main objective is to promote and preserve PAs.

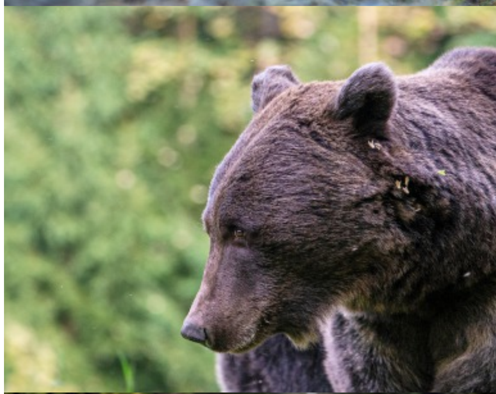
Study focus	
Visitor management	
Type of tool/method	
Application	
Type of data	
Spatial data	
Dimensions	
International	
Transferability to other regions	☑
Development level	
Experimental	

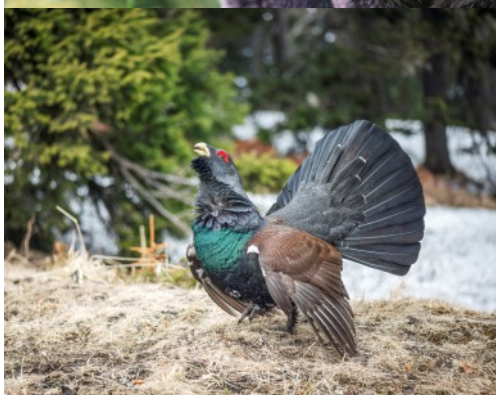
2.1.3.1. Methods

Digital transformation has significantly impacted visitor monitoring and the way tourists plan their itineraries. With the increasing popularity of outdoor apps, websites and a growing concern for promoting PAs, the **Digitize the Planet platform** has emerged. On outdoor apps, users can access not only official but also private tour suggestions, often without clear distinctions between them during the planning phase. Users tend to trust and assume the legitimacy of tour suggestions found on these platforms. To address this challenge, **Digitize the Planet** has committed to fostering responsible enjoyment of nature, aligning with regulations and without harming the environment. This is achieved through the comprehensive digitization of pertinent rules, encompassing laws and local agreements governing nature usage. The platform has been accessible online since autumn 2022.

2.1.3.2. Results

The **Digitize the Planet platform,** established in collaboration with participating conservation areas, serves as a repository for existing nature conservation regulations. On this online platform, participating PAs, administrations and associations have the capability to upload spatial and textual data relating to visitors. The association relies on





the knowledge of local partners who assume responsibility for providing the information that subsequently becomes available on the platform. PA managers have privileged access to create and update data specific to their respective PAs. While registration on the platform is free, a double authentication system has been implemented to prevent unauthorized access. Upon submitting an account creation request, which needs to be approved by the association, users are granted permission to upload regulations. **The platform already displays polygons for 50,000 PAs,** simplifying the process for new partners to incorporate rules for their respective territories. Digitize the Planet has established collaborative relationships with conservation areas predominantly in Germany and Austria. The uploaded rules are accessible in two formats: direct access via the **Digitize the Planet platform,** where users can access information about participating PAs, and through the use of an API key, enabling the integration of data into outdoor platforms such as **Outdooractive.**

2.1.3.3. Gaps

The Digitize the Planet platform is continuously expanding and acquiring additional regulations, primarily focusing on PAs in Western Europe. Furthermore, the data hosted on the platform are exclusively accessible to users of specific outdoor platforms that integrate the API into their interface. There remains a pressing requirement for increased collaboration with additional partners, particularly **OpenStreetMap,** which serves as the primary base map for numerous outdoor applications.

2.2. Wildlife monitoring

The surge in outdoor recreational activities in natural areas has led to growing concerns about the profound influence of tourism on wildlife. While human interactions with the natural environment can be enriching, they also carry potential threats to animal habitats and populations.

Recreational activities in natural areas can have far-reaching consequences on wildlife. Improper food storage by visitors can lead to conflicts with animals, often resulting in dire consequences *(Fortin et al., 2016)*. **Hunting** poses a significant threat to animal populations, albeit sometimes unintentional. The threat is further exacerbated by the expanding tourist industry, which can disrupt and even destroy natural habitats *(Kadafi et al., 2020)*. Schulze et al. *(2018)* conducted an extensive study assessing threats to terrestrial PAs worldwide. Their findings highlighted that disturbances from recreation rank as the second most significant threat to wildlife, surpassed only by hunting.

To comprehend the impact of visitors on wildlife in PAs, researchers employ diverse **monitoring methods.** One of the most accessible and cost-effective technique is the use of **wildlife cameras.** These devices autonomously capture images and short videos of animals passing in front of the camera, providing invaluable insights into wildlife behaviour *(Newey et al., 2015)*.

GPS collars are another indispensable tool used to track animal behaviour in response to human presence. Moena et al. *(2019)* utilized **GPS collars** to investigate the impact of human density on the behaviour of **brown bears** in **Sweden,** shedding light on how these animals adapt to changing landscapes that are influenced by tourism. Martin Wyttenbach's (Zurich University of Applied Sciences) research employed **GPS collars** to track the behaviour of **roe deer** when disturbed by mountain bikers, providing valuable insights into how recreational activities impact animal behaviour *(Wyttenbach et al., 2016)*.

In recent years, the utilization of **eco-acoustic sensors** to monitor the soundscape and its relationship with human disturbances has gained popularity. These sensors offer a non-intrusive means of understanding how wildlife reacts to human activities. Benjamin Cretois from the Norwegian Institute for Nature Research uses acoustic sensors to monitor soundscapes *(Cretois et al., 2022)*.

As **tourism** continues to flourish, it is imperative to strike a balance between **outdoor recreation** and **wildlife preservation.** Comprehensive monitoring strategies, including the use of **wildlife cameras, GPS collars,** and **eco-acoustic sensors, empower researchers** and **wildlife managers** to make informed decisions and develop effective conservation measures.

Martin Wyttenbach is a researcher at the **Life Sciences and Facility Management Institute of Natural Resource Sciences** at Zurich University of Applied Sciences. His research focusses on visitor monitoring, specifically on the influence of mountain bikers on nature.

Study focus
Wildlife monitoring
Type of tool/method
Device: GPS logger
Type of data
Spatial data
Dimensions
Local
Transferability to other regions ☑
Development level
Experimental

2.2.1. Human activities and wildlife disturbance, Martin Wyttenbach

2.2.1.1. Methods

This study, conducted near Zurich, examined the impact of new recreational forest patterns on **roe deer habitats,** specifically the **influence of mountain biking. GPS collars** were deployed **on 15 roe deer,** while **automatic counters** and **camera traps** monitored visitor behaviour. Additionally, **GPS loggers** were given to mountain bikers, facilitating spatial analysis of deer-visitor interactions. The study focussed on dawn and night-time observations due to the deer's heightened activity during these periods.

2.2.1.2. Results

Research findings reveal distinct visitation patterns in recreational areas, with higher weekend activity levels. Weekdays see early morning and evening outdoor activities like mountain biking, cycling, and running, while daytime sees more walkers. Deer activity also varies, as these animals are more active at night with peak activity at dawn and dusk.

In response to human presence, **deer consistently keep a 25-meter distance from forest roads during the day,** a distance that is reduced to **10 meters at night.** When encountering cyclists, they briefly flee but resume normal movement within about 10 minutes. However, on unofficial paths, deer tend to flee farther.
This study underscores the significant impact of human recreation on wildlife behaviour, particularly on unofficial trails. It emphasizes the need for wildlife conservation and management strategies that account for these dynamics *(Graf et al., 2018)*.

2.2.1.3. Gaps

This research specifically examined the **interactions between mountain bikers and roe deer.** Therefore, it does not provide sufficient grounds to make conclusions regarding generalized animal welfare. Future studies should expand their scope to provide a more comprehensive understanding of this topic *(Wyttenbach et al., 2016)*.

2.2.2. Impact of human noise disturbance on wildlife, Benjamin Cretois

Benjamin Cretois is a Senior IT Engineer at the **Norwegian Institute for Nature Research.** His work focusses on developing and using deep learning algorithms for biodiversity conservation and usage of artificial intelligence (AI) in bioacoustics.

Study focus
Wildlife monitoring
Type of tool/method
Device: Acoustic sensor
Type of data
Acoustic data
Dimensions
Local
Transferability to other regions ☑
Development level
Experimental

2.2.2.1. Methods

Modern technological advancements have revolutionized the field of wildlife research, allowing us to delve into the impact of visitor-induced noise disturbance in natural environments. This report explores a state-of-the-art method that utilizes **AI for eco-acoustic data analysis.** The methodology encompasses configuring recording devices, optimizing settings, data retrieval, storage options, supercomputing benefits, data labelling, and species classification. Benjamin presents a case study, the **"Sound of Norway" project,** which focused on biodiversity and human disturbance in natural landscapes. To capture relevant wildlife sounds, recording devices should be set to specific settings tailored to the research objectives. These settings may include selecting target species and optimizing recording duration. In order to balance data quality and file size, a recording duration of 5 minutes is considered optimal. This duration ensures that the files remain manageable and easily shareable while providing sufficient data for analysis. Recorded data can be retrieved through mobile connections or stored on SD cards, depending on field conditions. Mobile connections offer real-time data transfer convenience, while SD cards provide a reliable backup option. Following field data collection, recordings can be stored on cloud services, internal infrastructure, or in compliance with metadata standards. Storing data on the cloud facilitates collaboration with other research institutions and ensures data accessibility and security. For large-scale data analysis, access to supercomputers is advisable. Supercomputers significantly accelerate the process of recording analysis, allowing for efficient processing of extensive datasets. Accurate data labelling is crucial for analysis. Software tools like Raven Pro can assist in labelling wildlife sounds, making it easier to classify and detect specific species within the recordings. To classify and detect birds, Python is recommended as a programming language due to its versatility and powerful libraries for audio analysis. The **"Sound of Norway" project** exemplifies the application of this methodology. **Eco-acoustic devices** were strategically placed across Norway during the summer months. These devices were powered by solar energy and connected to the 3/4G mobile network, allowing for the seamless transfer of 5-minute recordings to cloud. The project also focused on measuring human disturbance using Voice Activity Detection (VAD) in natural landscapes.

2.2.2.2. Results

The research demonstrated that a customized model effectively detects human speech with precision. Data sourced from widely-frequented forest areas, favoured by hikers, assessed the model's proficiency in identifying human conversations at distances up to 10 meters. Enhancing the model's training involved incorporating location-specific soundscapes. Furthermore, findings revealed a direct relationship between human voice detection and peak traffic hours, determined by bus schedules. This study underscores the utility of VAD as a proxy for quantifying human disturbances with adequate temporal precision *(Cretois et al., 2022).*

2.2.2.3. Gaps

When analysing eco-acoustic data, legal considerations are paramount. Regulations concerning data containing identifiable human voices vary by country. Hence, collected data must undergo anonymization before subsequent analysis. To capture desired sounds effectively, landscape type must be factored in; for instance, in windy locales, protective measures are crucial.

2.3. Vegetation monitoring

Nature-based tourism and **outdoor recreation** have a **significant impact on vegetation.** This impact can result from both tourist infrastructure and the tourist activities themselves. Impacts from **tourist infrastructure** are linked to vegetation clearance due to construction projects. Examples include construction of hotels and other facilities that are designed to attract more visitors to the area. New buildings are often landscaped with non-native plants. This can cause significant problems for domestic flora, which may not be resilient to non-native competitors. Visitor activities in PAs are usually limited to officially signed trails. However, tourists often walk beyond designated trails. Such activity can lead to changes in hydrology, soils and vegetation including erosion, sedimentation and trampling *(Pickering & Hill, 2007)*.

The pressure of outdoor recreation can cause many problems within PAs. One of the identified human impacts is **trampling** of vegetation. It's a mechanical stressor, inflicting physical harm by crushing plant structures, with outcomes contingent on plant type and resilience. Trampling-induced defoliation reallocates water and nutrients to leaves at the expense of stems and roots, causing nutrient loss and diminished photosynthetic surfaces. This process heightens soil erosion vulnerability due to biomass depletion *(Kycko et al., 2017)*. Many studies were conducted over the years in different habitats around the world investigating vegetation responses to trampling. Various methodologies have been utilised, including disruptive surveys, site comparisons and experimental approaches. They showed that vegetation response to trampling depends on certain **conditions.** On the one hand, species respond differentially based on their innate resilience to stressors. On the other hand, in places of human recreational activity intensity of trampling can depend on the number of human passes, frequency of occurrence, spatial distribution, weather, habitat, plant growth form and soil type *(Pescott & Stewart, 2014)*.

In the **good-practice example below,** species resilience to human trampling is considered. The research of Marlena Kycko from University of Warsaw shows the possibility of using remote sensing for trampling assessment. This method can play an important role in research on human impacts and allow PA managers to control this process within their area of interest.

2.3.1. Impact on vegetation – Assessment of hyperspectral remote sensing for analysing the impact of human trampling, Marlena Kycko

Marlena Kycko is a researcher at the Department of Geoinformatics, Cartography and Remote Sensing at the University of Warsaw. Her research focusses on use of remote sensing for vegetation monitoring.

Study focus
Vegetation monitoring
Type of tool/method
Remote sensing
Type of data
Spatial data
Dimensions
Local
Transferability to other regions ☑
Development level
Experimental

2.3.1.1. Methods

Popular tourist destinations, specifically **natural mountain parks,** face vulnerability due to **trampling,** significantly impacting **alpine grasslands.** Furthermore, regenerating vegetation near tourist trails poses a considerable challenge. This report highlights a method for quantifying trampled vegetation. Despite the heterogeneity of vegetative communities, their spectral responses are influenced by various interferences, providing a composite response for multiple species. This study conducted measurements in a uniform alpine grassland adjacent to hiking trails, focusing on eight dominant species in the pilot area. **Measurements encompassed two distinct zones:** the first zone extended **up to 5 meters from the hiking trail,** representing the maximum distance tourists could deviate. The second, a control zone, spanned **between 5 and 10 meters from the trail.** Within these zones, polygons were delineated, each yielding 30 measurements. Data acquisition included spectrometric measurements in the 350-2500 nm range, total chlorophyll content assessment, and measurement of **photosynthetically active radiation (PAR).** The spectral characteristics of selected species formed the foundation for calculating various indices. Seven distinct groups of indices were employed to reveal plant parameters like chlorophyll, nitrogen or water content. The spectrometer-acquired data were cross-validated using the **Chlorophyll Content Index (CCI)** and **fAPAR.** All collected data underwent rigorous statistical analysis. Additionally, spectral characteristics of the vegetation were computed, as detailed in Kycko et al. *(2017)*.

2.3.1.2. Results

The research unveiled varying species resistance to human trampling and water stress, with noteworthy alterations in CCI values, Normalized Difference Vegetation Index (NDVI), and Water Band Index (WBI). A whopping 87% of polygons demonstrated these distinctions. The study pinpointed trampling-resistant species through remote-sensing vegetation indices and highlighted the impact of trampling on photosynthesis. Satellite imagery of the study area, guided by these indices, successfully unearthed traces of human trampling, notably marked by reduced vegetation vitality. This synergy of hyperspectral and biometric data offers a non-invasive approach for comprehensive vegetation monitoring.

2.3.1.3. Gaps

Executing field measurements consumes valuable time and resources, a critical factor for future research planning.

2.4. Erosion monitoring

The surge in **recreational activities** and **nature-based tourism,** such as **hiking** and **biking,** significantly impacts soil integrity. The proliferation of trails, especially in PAs, necessitates heightened attention to visitor-induced effects on vegetation, soil erosion, wildlife, and water quality – a concern spanning more than five decades *(Ballantyne & Pickering, 2015)*. Leveraging modern technologies, researchers enhance assessment complexity. A study in Cornwall melded advanced techniques like **Light Detection** and **Ranging (LiDAR), aerial photography,** and **on-site trail measurements** in a heathland ecosystem. Parameters encompassed soil loss, slope alteration, vegetation harm, and hydrological modelling. LiDAR furnished elevation, slope, and hydrological data, while aerial imagery gauged vegetation coverage *(Rodway-Dyer & Ellis, 2018)*.

Subsequently, Riccardo Roncella *(2.4.1)* presented a spectrum of emerging technologies for **trail erosion measurement.** Development of technology makes some techniques more available and possible to use in such research.

Remote sensing techniques also aid in trail reconstruction and mitigation of soil erosion. Researchers introduced a microtopographic profile indicator to detect exposed roots as an erosion monitoring tool. Validation relied on **3D point clouds** acquired via **terrestrial laser scanning (TLS)** *(Bodoque et al., 2017)*.

Field data collection on human impacts is resource-intensive and time-consuming, necessitating efficient tools for high-quality, sustained measurements. **UAVs,** commonly referred to as drones, offer a solution. These devices facilitate monitoring visitor patterns, assessing trail conditions, gauging vegetation health, and trampling effects. **UAVs** are acknowledged as a cost-effective method for such evaluations *(Ancin-murguzur & Munoz, 2020)*. A comprehensive illustration of **UAV** utility can be found in the description of Paweł Ćwiąkała's (AGH University of Technology and Science, Kraków) presentation below *(2.4.2)*.

2.4.1. Geomatics Techniques for Erosion Monitoring on Mountain Trails, Riccardo Roncella

Riccardo Roncella is a professor at the **Department of Engineering and Architecture at the University of Parma.** His research focusses on photogrammetry, especially innovative techniques for surveying and monitoring the environment.

Study focus
Erosion monitoring
Type of tool/method
Remote sensing, Device
Type of data
Optical data
Dimensions
Local
Transferability to other regions ☑
Development level
Experimental

2.4.1.1. Methods

New erosion monitoring techniques have emerged on the market, presented as a practical summary. To quantify soil erosion, various remote sensing and geomatic methods are available, including **satellite imagery, airborne/UAV photogrammetry, laser scanning, GNSS,** and **traditional survey techniques.** The choice of method depends on factors such as erosion scale, triggering elements, and accessibility. **Four technologies were compared in the presentation:** UAV (photogrammetry and laser scanning), spherical imaging, TLS, and Close-range photogrammetry. All methods offer identical outputs, suitable for challenging conditions, and user-friendly.

UAVs provide flexibility in sensor installation, yielding both geometric and thematic data. Approximately 10km^2 of data can be acquired in a single day of fieldwork.

Spherical imaging represents an innovative approach, capturing multiple simultaneous images, typically using **fisheye cameras,** to cover the sensor's entire surroundings. The device can be backpack-mounted, making it suitable for less accessible areas, with resolutions reaching up to **2 mm/pixel.**

TLS comes in fixed (tripod-mounted) and mobile (handheld) versions. A single scan covers a limited area (10 x 10 m), requiring multiple scans to overcome occlusions.

Close-range photogrammetry relies on photographs taken by a camera, focusing on a small area to achieve high accuracy and resolution. This low-cost method allows the use of even smartphone cameras.

2.4.1.2. Results

The techniques outlined in the presentation offer a comprehensive range of data outputs, including **geometric vector primitives, 3D models, raster models,** and **orthophotos.** These geomatic methods deliver accuracy, completeness, and flexibility, rendering them well-suited for deployment, even in remote and challenging terrains.

2.4.1.3. Gaps

In **UAV surveying,** obstacles such as trees, bushes, and a low canopy can impede data completeness. Conversely, spherical imaging selectively captures data from the immediate surroundings. In the context of close-range photogrammetry, anyone can capture pictures, but this can pose challenges, as it may lack reference points required for further processing—often due to a **lack of professional photography training.**

Paweł Ćwiąkała is a researcher at the **Department of Engineering Surveying and Civil Engineering at the AGH University of Technology and Science in Kraków.** His research focusses on usage of modern measurement technologies such as UAVs for geodetic monitoring of natural and industrial objects.

Study focus
Erosion monitoring
Type of tool/method
Remote sensing
Type of data
Spatial data
Dimensions
Local
Transferability to other regions ☑
Development level
Experimental

2.4.2. Assessment of the possibility of using UAVs for the Documentation of Hiking Trails in Alpine Areas, Paweł Ćwiąkała

2.4.2.1. Methods

The **UAV method** proves invaluable for assessing **soil erosion along hiking trails.** The study focused on hiking trails situated between the lower subalpine zone and alpine glades. Assessing the trail's current state involved utilizing photogrammetric techniques and cross-referencing them with archival data from the region. Crucial to the methodology were the initial steps of fieldwork planning and data collection, significantly impacting subsequent results.

Firstly, **meticulous planning of UAV missions is essential.** In this instance, a **multi-rotor UAV** was chosen, highly recommended for mountainous hiking paths. Aligning measurements parallel to the mountain is pivotal. Georeferenced data delivery is facilitated through the utilization of ground control points, an essential element of the process.

The second step involves detailed field mission planning in the designated area, incorporating **control points.** Typically, it's advisable to employ around **20 control points per 1km².** These control points, whether natural features or pre-placed targets, ensure an accuracy level of 20-30 mm. Radio modems prove to be convenient for communication in mountainous terrain.

Another crucial aspect is **field data collection,** necessitating proper landing areas, especially when deploying larger, heavier UAVs. Ideal field conditions involve favourable weather, ideally with a high cloud cover. Subsequently, the collected data undergo preliminary processing, involving photo alignment and bundle block adjustment.

2.4.2.2. Results

UAVs offer versatile applications in monitoring landslides, soil and slope erosion, leveraging flight-generated products such as **digital elevation models (DEM)** and **orthophotomosaics.** The collected data can be cross-referenced with TLS, ensuring high accuracy levels. Subsequent analysis enables the quantification of erosion and accumulation along hiking trails.

Furthermore, when measurements are taken under varying conditions, including both snowy and snow-free periods, it becomes possible to calculate snow thickness. Advanced analyses extend to slope calculations for the hiking trail. By comparing multiple sessions over an extended timeframe, orthomosaics can be examined, facilitating the assessment of trail erosion levels, the progression of forest succession, and the impact of anthropogenic denudation on changes in the tree line *(Ćwiąkała et al., 2018).*

2.4.2.3. Gaps

Transporting the UAV device to mountainous regions can pose challenges due to its weight, particularly for smaller research teams.

2.5. Pollution monitoring

Litter pollution poses an immediate and critical threat to the natural environment. Escalating global waste production, coupled with inefficient waste management practices, intensifies pollution in water bodies, soil, and living organisms. Within the scope of the **HUMANITA project,** the primary focus centers on litter found in marine waters and on beaches. Marine litter can be observed both on shorelines and floating anywhere from the sea floor to the surface. This issue is particularly pronounced in coastal and marine PAs, where litter accumulates, endangering species and their habitats. The consequences range from entanglement and ingestion to the bioaccumulation and biomagnification of toxic substances released from accumulated waste *(Fossi, et al., 2022)*.

Numerous ongoing projects worldwide are dedicated to **studying marine** and **beach litter,** shedding light on this well-documented problem common to many regions. Additionally, many organizations have developed specialized guidelines for monitoring marine debris, such as **OSPAR** – a forum for collaborative efforts to safeguard the marine environment. In 2010, **OSPAR** released guidelines for monitoring marine litter on beaches, outlining methodologies for assessing debris. This includes the selection of reference beaches, sampling units, timing considerations, and litter identification techniques (OSPAR, 2010). Furthermore, the **INTERREG** project **Plastic Busters** devised specific surveys to simplify the identification of collected marine litter *(Fossi, et al., 2022)*.

It's worth noting that plastic and microplastic pollution extends beyond maritime environments. Its presence in terrestrial ecosystems and its impact on soil-dwelling organisms remain relatively underexplored. Research conducted by Davorka *(2022)* examined soil samples from agricultural fields and urban parks, including earthworm casts. This study successfully extracted microplastics from the samples and measured their size. Notably, the research revealed the retention of smaller microplastics within earthworm organisms, potentially leading to increased mortality and reduced growth rates.

3. Factsheets of **good-practice** examples

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Monitoring Recreational Trail Usage in an Urban Park

Ádám Varga, Linda Magyar, **CEEweb**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Camera traps, Visitor counters
Type of data	Alphanumerical data, Optical data
Frequency / interval (smallest)	Yearly
Transferability to other region	☑
Dimension	Regional
Development level	Established
Details on the monitoring site	
Place of monitoring	Donau-Auen National Park in Vienna
Country of monitoring	Austria
Landscape type	Forest
Protected Area Category	National Park
Organisation involved	
Type of organization	Park management
Name of organisation	University of Natural Resources and Life Sciences, Vienna

Methods

Installed a passive infrared counter (Ecocounter Ecotwin) and a time-lapse camera at the park's main entrance.
Ensured data protection by using low-resolution cameras placed at enough distance from visitors.
Documented date, day, time, group size, movement direction, activity type, and the number of dogs.

Results

Recorded a 20 percent undercount using the infrared counter.
Analyzed the percentage of user groups, including walkers, cyclists, and cars.

Gaps

The undercounting issue resulted from groups of walkers passing the counter side by side.

References

Kahler, A., & Arnberger, A. (2008). A comparison of passive Infrared counter results with time lapse video monitoring at a shared urban recreational trail. MMV4. Vienna, Austria, 485-489.

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Utilizing STRAVA Data for Visitor Activity Analysis

Lilia Schmalzl, **CUAS**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Application
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	Regional
Development level	Experimental
Details on the monitoring site	
Place of monitoring	Black Forest National Park
Country of monitoring	Germany
Landscape type	Unrelated
Protected Area Category	National Park
Organisation involved	
Type of organization	Research company
Name of organisation	University of Münich

Methods

Conducted analysis on STRAVA data with a focus on qualitative information.
Qualitative information, distinguishing between local and tourist users.
Identifying activity types, including hiking, biking, and mountain biking.
Extracting spatial information such as route length, speed, and total time.
Employing density analysis techniques, including hotspot and raster (heatmap) mapping.

Results

Noted a predominant 94% male user demographic in the area.
Found that 56% of recorded tracks were from mountain bikers.
Identified the main visitor activity occurring on weekends in late spring and summer during midday hours.

Gaps

Acknowledged that while STRAVA data analysis provides valuable complementary visitor information, it may not be fully representative for comprehensive visitor monitoring.

References

Schallinger, T., & Rolf, W. (2018). GPS-Based Visitor Monitoring in Protected Areas Using Mobile Tracking Application Data - A Case Study in Black Forest National Park. Retrieved September 14, 2023, from https://mmv.boku.ac.at/refbase/files/schallinger_teresa_rolf_werner-2018-gps-based-visitor-monitoring.pdf

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Utilizing Outdoor App Data for Visitor Spatial Analysis

Lilia Schmalzl, **CUAS**

Details on the monitoring

Study focus	Visitor monitoring
Type of tool / method	Application, Visitor counter
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site

Place of monitoring	Bavarian Forest National Park
Country of monitoring	Germany
Landscape type	Unrelated
Protected Area Category	National Park

Organisation involved

Type of organization	Research company
Name of organisation	University of Natural Resources and Life Sciences, Vienna

Methods

Analyzed data from outdoor apps (GPSies, Outdooractive, Komoot) to assess the spatial distribution of hikers.
Utilized visitor counters (EcoCounter Pyrosensors) for data comparison.
Applied a 50 m buffer around counters to evaluate data from platforms and counters.
Calculated hiker hotspots for spatial analysis.

Results

Successfully identified visitor hotspots and observed temporal variations.
Demonstrated that the methodology is cost-effective and requires minimal time investment.

Gaps

Noted that the visitor profile obtained may not represent all park visitors.
Highlighted that Volunteered Geographic Information (VGI) data cannot fully replace traditional visitor surveys.
Acknowledged that the popularity of different platforms may vary in other regions.

References

Horst, L., Taczanowska, K., Porst, F., & Arnberger, A. (2023). Evaluation of GNSS-based Volunteered Geographic Information for assessing visitor spatial distribution within protected areas: A case study of the Bavarian Forest National Park, Germany. Applied Geography, 150, 102825. https://doi.org/10.1016/j.apgeog.2022.102825

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

STRAVA Metro – supporting active transportation planning

Zuzanna Kieliszek, **CUAS**

Details on the monitoring

Study focus	Visitor monitoring
Type of tool / method	Application
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	International
Development level	Experimental

Details on the monitoring site

Place of monitoring	/
Country of monitoring	/
Landscape type	Unrelated
Protected Area Category	Unrelated

Organisation involved

Type of organization	Service provider
Name of organisation	STRAVA Metro

Methods

STRAVA Metro provides aggregated, anonymized and standardized data.
STRAVA segments are documenting user information about trail use.

Results

Developed a dashboard for visualizing and downloading data on segments.
Enabled the visualization of spatial-temporal distribution of visitors and user groups through various tools like dashboards and heatmaps, without requiring GIS expertise.

Gaps

STRAVA data are not representative for all visitors.

References

Strava (n.d.) Retrieved 14.09.2023 from https://metro.strava.com/

Visitor Monitoring Visitor Management Wildlife Monitoring Vegetation Monitoring Erosion Monitoring Pollution Monitoring

Information on mountain bike trail use – Trailforks

Zuzanna Kieliszek, **CUAS**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Application
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	International
Development level	Experimental

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	Unrelated
Protected Area Category	Unrelated

Organisation involved	
Type of organization	Service provider
Name of organisation	Trailforks

Methods

Trailforks is an outdoor app mostly for mountain bikers.
Trailstats and visitor stats can be visualized on the website.

Results

Visitor and trail stats can be analyzed on the platform.
Spatial data can be uploaded.
Information on the trails can be uploaded.

Gaps

Trailforks data are not representative for all visitors.

References

Trailforks (n.d.) Retrieved 14.09.2023 from https://www.trailforks.com/

Visitor Monitoring Visitor Management Wildlife Monitoring Vegetation Monitoring Erosion Monitoring Pollution Monitoring

Information on touristic points of interest – Wikiloc

Zuzanna Kieliszek, **CUAS**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Application
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	International
Development level	Experimental

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	Unrelated
Protected Area Category	Unrelated

Organisation involved	
Type of organization	Service provider
Name of organisation	Wikiloc

Methods

Wikiloc is an outdoor app provider for different user groups (hikers, bikers, etc.).
Wikiloc shows viewpoints, rest places, etc. on the map along the routes.

Results

Data are provided on a dashboard and can be analysed by the user.

Gaps

Wikilog data are not representative for all visitors.

References

Wikiloc (n.d.) Retrieved 14.09.2023 from https://de.wikiloc.com/

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Impact of COVID-19 on Recreational Activities in Protected Areas

Zuzanna Kieliszek, **CUAS**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Application
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	International
Development level	Experimental

Details on the monitoring site	
Place of monitoring	40 protected areas across Southeast Queensland
Country of monitoring	Australia
Landscape type	Unrelated
Protected Area Category	National Parks, Conservation Parks

Organisation involved	
Type of organization	Research company
Name of organisation	Griffith University, Australia

Methods

Analyzed the surge in recreational activities within protected areas during the COVID-19 pandemic.
Utilized Trailforks and Wikiloc data sources.
Examined activity types (hiking, mountain biking).
Tracked the number of routes created per month and year.
Explored characteristics of users, including unique riders, gender, and age.

Results

Mountain biking emerged as a favored activity in proximity to urban areas.
Hiking exhibited higher popularity in remote and secluded regions.
Noted that 70% of mountain bikers are within the 30 to 50-years of age.
Revealed a relatively low representation of women in mountain biking, constituting only 10% of participants.

Gaps

Different popularity of outdoor app use in various regions, resulting in data gaps.

References

Smith, I., Velasquez, E., Norman, P., & Catherine Marina Pickering. (2022). Effect of the COVID-19 pandemic on the popularity of protected areas for mountain biking and hiking in Australia: Insights from volunteered geographic information. Journal of Outdoor Recreation and Tourism, 100588–100588.
https://doi.org/10.1016/j.jort.2022.100588

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Monitoring Recreational Activities in Metropolitan Areas

Zuzanna Kieliszek, **CUAS**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Application
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Lisbon Metropolitan Area
Country of monitoring	Portugal
Landscape type	/
Protected Area Category	Nature Park, Landscape protection area

Organisation involved	
Type of organization	Research company
Name of organisation	Social and Educational Research Group on Physical Activity and Sport (GISEAFE)

Methods

Conducted an analysis of outdoor app data (GPSies) to monitor recreational visitors in a metropolitan area.
Utilized selective search queries for data collection, focusing on:
Activity types such as hiking, biking, and mountain biking.
Assessment of users' level of commitment.

Results

Identified undesirable behaviors, including trespassing and the creation of informal trails.
Located main entrances and hotspots within the metropolitan area.
Observed variations in recreational activity types and usage patterns across different regions.

Gaps

Acknowledged that GPSies data may not represent all visitor groups.

References

Nogueira Mendes, R. M., Farías-Torbidoni, E. I., & da Silva, C. P. (2023). Squeezing the most from volunteered geographic information to monitor mountain biking in peri-urban protected and recreational areas at a metropolitan scale. Journal of Outdoor Recreation and Tourism, 42, 100624. https://doi.org/10.1016/j.jort.2023.100624

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Monitoring Recreational Visitors in Protected Areas Using STRAVA Data

Zuzanna Kieliszek, **CUAS**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Application
Type of data	Spatial data
Frequency / interval (smallest)	More than one year
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Protected natural areas in USA
Country of monitoring	USA
Landscape type	/
Protected Area Category	Other

Organisation involved	
Type of organization	Research company
Name of organisation	University of Montana

Methods

Utilized the fitness app STRAVA for visitor monitoring in protected areas.
Collected STRAVA data through heatmaps, focusing on sites with high volumes of biking, running, and mixed use.
Overlaid georeferenced map images with official trail and road systems.

Results

Heatmaps unveiled visitor flow networks and usage patterns within protected areas.
Identified areas with unofficial trail usage and provided visualizations of user activity levels.
Recognized unsustainable topography on unofficial trails.

Gaps

Note that this approach is particularly valuable for protected areas near urban areas with higher user activity levels.
STRAVA data may not fully represent all visitor groups.

References

Rice, W. L. (2019). Detailing an Approach for Cost-Effective Visitor-Use Monitoring Using Crowdsourced Activity Data. The Journal of Park and Recreation Administration.
https://doi.org/10.18666/jpra-2019-8998

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Visitor Monitoring Approaches in Södra Jämtlandsfjällen, Europe

Dana Sitányiová, **University of Žilina**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Literature Review
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	More than one year
Transferability to other region	☑
Dimension	Regional
Development level	Established

Details on the monitoring site	
Place of monitoring	Södra Jämtlandsfjällen
Country of monitoring	Norway
Landscape type	Rock, Grassland
Protected Area Category	National Park

Organisation involved	
Type of organization	Research company
Name of organisation	European Tourism Research Institute Mitthogskolan

Methods

Literature review on visitor monitoring methods.
Tested various visitor monitoring methods in Södra Jämtlandsfjällen.
Employed surveys, questionnaires, mapping of physical traces, visitor counting, permits, tickets, and manual observation.

Results

Overview of methods to detect visitor numbers, characteristics, distribution, and attitudes.
The report offers reflections and recommendations on each method.

Gaps

Lacks standardized monitoring methods.
Calls for modernization and complementary techniques.

References

Vuorio, T., Emmelin, L., & Sandell, K. (n.d.). Methods for monitoring outdoor recreation and tourism in large nature areas -the case of Södra Jämtlandsfjällen.
https://www.diva-portal.org/smash/get/diva2:228231/FULLTEXT01.pdf

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Monitoring Visitor Patterns Through Social Media in Mountain-Protected Areas

Dana Sitányiová, **University of Žilina**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Social media
Type of data	Alphanumerical data, Spatial data
Frequency / interval (smallest)	More than one year
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Aconcagua Provincial Park Kosciuszko National Park
Country of monitoring	Argentina, Australia
Landscape type	/
Protected Area Category	Nature Park

Organisation involved	
Type of organization	Research company
Name of organisation	North Carolina State University

Methods

Utilized social media (Flickr) to analyze geotagged photos in two mountain-protected areas (Argentina and Australia).
Detected temporal and spatial user patterns.
Compared data with ground-recorded visitor statistics.

Results

Heatmap reveals high user volume locations.
Significant correlation found between the number of photos and visitation.

Gaps

Potential sampling bias in social media-based data.
Variability in smartphone availability and usage for photo sharing among and within countries.

References

Walden-Schreiner, C., Rossi, S. D., Barros, A., Pickering, C., & Leung, Y.-F. (2018). Using crowd-sourced photos to assess seasonal patterns of visitor use in mountain-protected areas. Ambio, 47(7), 781–793. https://doi.org/10.1007/s13280-018-1020-4

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Stakeholder Perceptions of Environmental Protection in Central Karakoram National Park, Pakistan

Ádám Varga, Linda Magyar, **CEEweb**

Details on the monitoring	
Study focus	Visitor monitoring
Type of tool / method	Survey/interview
Type of data	Alphanumerical data
Frequency / interval (smallest)	One time
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Central Karakoram National Park (CKNP) in Pakistan
Country of monitoring	Pakistan
Landscape type	Forest
Protected Area Category	National park

Organisation involved	
Type of organization	Research company
Name of organisation	University of Southern Queensland

Methods

Conducted an analysis of the perception of environmental protection and resource conservation among tourism stakeholders in Central Karakoram National Park, Pakistan.
Surveyed various stakeholder groups, including tourism enterprises, protected area authorities, local communities, and tourists.
Utilized the New Ecological Paradigm scale for the survey.
Analyzed survey data using SPSS.

Results

Protected area authorities and local communities demonstrated the highest eco-centric interest in environmental protection.
Tourists exhibited a high level of interest in egoistic values.
Stakeholders expressed concerns about the negative human impact on the environment while also showing interest in benefiting from the protected area's resources.

Gaps

Limited tourist sample size due to accessibility issues associated with high-altitude basecamps and time-consuming survey collection.

References

Imran, S., Alam, K., & Beaumont, N. (2014). Environmental orientations and environmental behaviour: Perceptions of protected area tourism stakeholders. Tourism Management, 40, 290-299.
https://doi.org/10.1016/j.tourman.2013.07.003

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Monitoring of visitors in protected wetlands on Pohorje Mountain range – Slovenia

Danijela Modrej, Urosh Grabner, **EGTC Geopark Karawanken/Karavanke**

Details on the monitoring	
Study focus	Visitor monitoring, Visitor management
Type of tool / method	Visitor counter, Field survey
Type of data	Spatial data, Alphanumerical data, Optical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Protected wetlands on Pohorje Mountain range
Country of monitoring	Slovenia
Landscape type	Bog, Grassland, Forest
Protected Area Category	Natura 2000

Organisation involved	
Type of organization	Other: National institution
Name of organisation	The Institute of the Republic of Slovenia for Nature Conservation (IRSNC)

Methods

Analyzed visitor counter data to identify peak visitation times and impacts on an hourly, weekly, monthly, and yearly basis.
Utilized qualitative data to gain insights into the demographics of visitors.
Implemented visitor management strategies.

Results

Conducted trail network inventory.
Installed sensors at entry points on three active raised bogs.
Over 53,000 visitors are recorded annually, with the highest number of visitors in August. The busiest times with the highest number of visits are weekends and holidays.
Identified the areas that require adjustments in trail infrastructure.
Implemented new information infrastructure and trail updates.

A total of 2000 meters of wooden paths were reconstructed and a watching tower renovated. Parallel, a new wooden footpath was put into use, with a purpose to shift visiting from natural sensitive bogs to a less sensitive one.

Gaps

It is important to stress the importance of working together in a coordinated manner.
In order to make informed decisions, it is necessary to conduct additional research.

References

Gulič, J., & Štruc, S. (n.d.). Monitoring and management of visitors on Pohorje Mountain active raised bogs (Slovenia). Retrieved September 14, 2023, from https://mmv.boku.ac.at/refbase/files/2014–Gulic_et_al_Monitoring_and_management_of_visitors.pdf

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Monitoring disturbance of motorized vehicles on Pohorje Mountains

Urosh Grabner, Danijela Modrej, **EGTC Geopark Karawanken/Karavanke**

Details on the monitoring	
Study focus	Visitor monitoring, Visitor management
Type of tool / method	Visitor counter
Type of data	Alphanumerical data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	Local
Development level	Established

Details on the monitoring site	
Place of monitoring	Pohorje Mountains
Country of monitoring	Slovenia
Landscape type	Grassland
Protected Area Category	Natura 2000

Organisation involved	
Type of organization	Other: National institution
Name of organisation	The Institute of the Republic of Slovenia for Nature Conservation (IRSNC)

Methods

Utilization of ferromagnetic sensors to monitor disturbances in the natural environment caused by motorized vehicles, snowmobiles and bikes. The devices were installed on forest roads where traffic is permitted only for forest management as well as on hiking trails.
The aim was the monitoring of illegal vehicle activity.

Results

As a result of the study, based on collected data, was created a pattern of use of forest roads. Forest management installed road signs with time-limited visits and raised 5 roadblocks to protect sensible areas. Studies showed that the maximum value of journeys was detected in wintertime (February, March) between 8 p.m. and 6 a.m. (presumably mostly snowmobiles).

Gaps

The study doesn't show the influence of vehicles on the environment. The need to expand monitoring and analysis.

References

Gulič J., et al. (2016), Monitoring of disturbances in the natural environment on Pohorje Mountain (Slovenia), MMV8, Novi Sad

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Visitor Monitoring and Management in Outdoor Recreation Areas

Balázs Megyeri, **Bükk National Park**

Details on the monitoring	
Study focus	Visitor Monitoring, Visitor management
Type of tool / method	Literature review
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	/
Protected Area Category	/

Organisation involved	
Type of organization	Research company
Name of organisation	University of Natural Resources and Life Sciences, Vienna

Methods

A systematic overview on methods used for visitor monitoring in recreational areas.
Focus on quantitative methods like direct observation, video observation, counting devices, registration books.
Presented best combinations of methods depending on the objectives of monitoring.

Results

Implemented management responses to control tourist impacts, including:
New and enhanced trail infrastructure for hikers and mountain bikers.
Improved functional signposting.
Information campaigns to mitigate user conflicts through manuals and guidelines.

Gaps

While the article is slightly dated, the methodology remains relevant.

References

Muhar, A., Arnberger, A., & Brandenburg, C. (2002). Monitoring and Management of Visitor Flows in Methods for Visitor Monitoring in Recreational and Protected Areas: An Overview (pp. 1–6).

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Mountain Bike Visitor Management Resources

Lilia Schmalzl, **CUAS**

Details on the monitoring	
Study focus	Visitor Monitoring, Visitor management
Type of tool / method	Website
Type of data	Alphanumerical data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	National
Development level	Established

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	/
Protected Area Category	/

Organisation involved	
Type of organization	Association
Name of organisation	Mountainbike Tourismusforum Deutschland e.V.

Methods

Developed a comprehensive collection of tools and information for managing mountain biker visitors.
Included examples of good-practices in visitor management.

Results

Organized information into the following sections:
General insights on digital visitor management.
Toolkit factsheets detailing the use of various visitor management tools.
Showcases good-practice examples and fostered a network of knowledge sharing.

Gaps

Currently available only in the German language, with plans for an English translation in the near future.

References

Natkit (n.d.) Retrieved 14.09.2023 from https://www.natkit.org/

Visitor Monitoring | **Visitor Management** | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Environmental and Visitor Management in Chinese Conservation Reserves

Balázs Megyeri, **Bükk National Park**

Details on the monitoring	
Study focus	Visitor management
Type of tool / method	Survey / interview
Type of data	Alphanumerical data
Frequency / interval (smallest)	One-time
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site	
Place of monitoring	1,200 conservation reserves in China
Country of monitoring	China
Landscape type	/
Protected Area Category	Unrelated

Organisation involved	
Type of organization	Research company
Name of organisation	Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences / International Chair in Ecotourism Research, Griffith University

Methods

Conducted an analysis of visitor and environmental management practices in China.
Utilized a multiple-choice survey questionnaire.
Surveyed 1,200 individual conservation reserves with a 92.5% response rate.
Examined 160 parameters related to tourism infrastructure, visitor management, community involvement, environmental management, and environmental impacts.

Results

Discovered a significant gap in park visitation and financing between long-standing and young conservation parks.
Older parks tend to invest more in visitor infrastructure to reduce environmental impacts.
Identified key conservation concerns, including air and water pollution, as well as the illegal sale of threatened species.

Gaps

The proposed visitor management practices may only be partially applicable in Europe due to variations in land use management regulations.

References

Zhong, L., Buckley, R. C., Wardle, C., & Wang, L. (2015). Environmental and visitor management in a thousand protected areas in China. Biological Conservation, 181, 219–225. https://doi.org/10.1016/j.biocon.2014.11.007

Visitor Monitoring | **Visitor Management** | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Digitize the Planet: Advancing Nature Conservation with Technology

Lilia Schmalzl, **CUAS**

Details on the monitoring	
Study focus	Visitor management
Type of tool / method	Application
Type of data	Spatial data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	International
Development level	Experimental

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	/
Protected Area Category	/

Organisation involved	
Type of organization	Association
Name of organisation	Digitize the Planet e.V.

Methods

Digitization of protected area info for eco-friendly planning.
Collaborating with local stakeholders to tap into regional expertise.

Results

Accessible protected area database via API for outdoor apps.
Encouraging PA managers to contribute conservation data.
Empowering visitors with informed decision-making.

Gaps

Need for more protected areas to share information.
Potential for increased outdoor app integration.

References

Digitize the planet (n.d.) 14.09.2023 Retrieved from https://digitizetheplanet.org/en/

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Relative Effects of Recreational Activities on Terrestrial Wildlife

Jozef Limánek, **National Park Malá Fatra**

Details on the monitoring

Study focus	Visitor monitoring, Wildlife monitoring
Type of tool / method	Camera traps
Type of data	Spatial data, Alphanumerical data, Optical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site

Place of monitoring	South Chilcotin Mountains Provincial Park
Country of monitoring	Canada
Landscape type	Forest, Grassland, Rock
Protected Area Category	Provincial Park

Organisation involved

Type of organization	Research company
Name of organisation	Institute for Resources, Environment and Sustainability, University of British Columbia, Vancouver

Methods

Camera traps used in a 550 km^2 area with a hexagonal grid to monitor medium- and large-bodied wildlife species and human activities.
Counted 14 individual mammals, birds, and amphibians.
Counted 4 individual visitor activities: hikers, horseback riders, mountain bikers, and motorized vehicles.
Species classified using the Camelot software package.

Results

Developed models to predict species occurrence probability, considering recreational and environmental variables.
Calculated the Avoidance-Attraction Ratio for different user activities.
Detected 2 negative associations between mountain biking and moose as well as grizzly bears.
Found a slight negative correlation among all 13 analyzed species.
Identified mountain bikers and motorized vehicles as having the highest impact.

Gaps

The study's findings are specific to Canadian fauna.

References

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

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Integrating Camera Traps and Acoustic Recorders for Fauna and Human Disturbance Monitoring

Ádám Varga, Linda Magyar, **CEEweb**

Details on the monitoring

Study focus	Visitor monitoring, Wildlife monitoring
Type of tool / method	Literature review
Type of data	Acoustic data, Optical data
Frequency / interval (smallest)	No information
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site

Place of monitoring	/
Country of monitoring	/
Landscape type	/
Protected Area Category	/

Organisation involved

Type of organization	Research company
Name of organisation	Colorado State University, USA

Methods

Conducted a literature review focusing on the utilization of acoustic and wildlife camera data for analyzing human disturbances on fauna.
Utilized wildlife cameras to capture medium- and large-bodied mammals, visitor numbers, and activities.
Employed audiosensors to capture sounds from amphibians, cicadas, birds, bats, and the human soundscape.

Results

Highlighted challenges, including the cost of equipment and the management of large datasets.

Gaps

Costly equipment.
Big data management.

References

Buxton, R. T., Lendrum, P. E., Crooks, K. R., & Wittemyer, G. (2018). Pairing camera traps and acoustic recorders to monitor the ecological impact of human disturbance. Global Ecology and conservation, 16, e00493. https://doi.org/10.1016/j.aeolia.2010.03.001

Evaluating Recreation's Impact in Western Canada

Zuzanna Kieliszek, **CUAS**

Details on the monitoring	
Study focus	Visitor monitoring, Wildlife monitoring
Type of tool / method	Application, Governmental data
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continous
Transferability to other region	☑
Dimension	Regional
Development level	Established

Details on the monitoring site	
Place of monitoring	Alberta and British Columbia
Country of monitoring	Canada
Landscape type	Forest
Protected Area Category	National Park

Organisation involved	
Type of organization	Research company, Association
Name of organisation	Yellowstone to Yukon Conservation Initiative

Methods

Conducted a trail mapping project in Western Canada to assess the human footprint generated by recreational activities.
Collected trail geodata from both official (documented) and crowdsourced (undocumented) sources, including government records, protected areas, OpenStreetMap (OSM), and Trailforks.
Defined the intended purpose for each trail.
Performed a comparative analysis of government-sourced and crowdsourced trail data.
Analyzed trail layers in relation to terrain features and wildlife covariates.

Results

Discovered that 73% of trails were officially documented, while 27% remained undocumented.
Identified OpenStreetMap (OSM) as the primary source of undocumented trails.

Gaps

Recognized the necessity for a large-scale effort to centralize trail data and strategically plan recreational use.

References

Loosen, A., Capdevila, T. V., Pigeon, K., Wright, P., & Jacob, A. L. (2023). Understanding the role of traditional and user-created recreation data in the cumulative footprint of recreation. Journal of Outdoor Recreation and Tourism, 100615.
https://doi.org/10.1016/j.jort.2023.100615

Impact of Human Disturbance on Wildlife Activity in Bükk Hills, Hungary

Balázs Megyeri, **Bükk National Park**

Details on the monitoring	
Study focus	Visitor monitoring, Wildlife monitoring
Type of tool / method	Camera trap
Type of data	Alphanumerical data, Optical data
Frequency / interval (smallest)	Continuous
Transferability to other region	☑
Dimension	Local
Development level	Established

Details on the monitoring site	
Place of monitoring	Bükk National Park
Country of monitoring	Hungary
Landscape type	Forest
Protected Area Category	National Park

Organisation involved	
Type of organization	Park management, Research company
Name of organisation	University of Debrecen, Bükk National Park Directorate, WWF Hungary, University of Lisbon

Methods

Camera traps used to record wildlife frequency, daily activity patterns, and human activity types.
Focus on species: grey wolves, red foxes, red deer, wild boars, and European roe.
Focus of human activity types: hikers, vehicles, mountain bikers
R statistical environment used for analysis.

Results

Predators and game mainly active at night, while human activity peaks midday.
Human activity can shift diurnal animals to nocturnal behavior.
Human disturbance has a greater impact on big game species than the presence of wolves.

Gaps

Lack of data to quantify the disturbance.

References

Z Szabó, Gombkoto, P., Csaba Aranyi, László Patkó, Gigler, D., & Barta, Z. (2022). The effect of grey wolf (Canis lupus) and human disturbance on the activity of big game species in the Bükk Hills, Hungary. BioRxiv (Cold Spring Harbor Laboratory).
https://doi.org/10.1101/2022.09.21.508874

Literature Review on the Impacts of Recreational Activities on Brown Bear Habitats

Jozef Limánek, Michal Kalaš, **National Park Malá Fatra**

Details on the monitoring	
Study focus	Visitor management, Wildlife monitoring
Type of tool / method	Survey/interview, Literature review
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	International
Development level	/

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	/
Protected Area Category	Unrelated

Organisation involved	
Type of organization	Research company
Name of organisation	University of Montana

Methods

Conducted a literature review of the impact of recreational activities in brown bear habitats.
Analyzed the interactions between brown bears and visitors.
Explored potential effects and proposed management solutions.
Identified research needs in the field.

Results

Brown bears exhibited behaviours of habituation, temporal avoidance, or spatial avoidance in response to human presence.
Spatial displacement of bears can have fatal consequences.
Predictable recreational activities, such as bear-viewing platforms with set opening hours, allow bears to habituate to human presence.

Gaps

The research was conducted in North America, and the findings may differ due to regional variations in factors affecting brown bears, as compared to Europe.

References

Fortin, J. K., Rode, K. D., Hilderbrand, G. V., Wilder, J., Farley, S., Jorgensen, C., & Marcot, B. G. (2016). Impacts of Human Recreation on Brown Bears (Ursus arctos): A Review and New Management Tool. PLOS ONE, 11(1), e0141983.
https://doi.org/10.1371/journal.pone.0141983

Behavioural Responses of Brown Bears to Human Encounters

Jozef Limánek, Michal Kalaš, **National Park Malá Fatra**

Details on the monitoring	
Study focus	Wildlife monitoring
Type of tool / method	GPS loggers
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	More than one year
Transferability to other region	☑
Dimension	Local, Regional
Development level	Experimental

Details on the monitoring site	
Place of monitoring	South-central Sweden
Country of monitoring	Sweden
Landscape type	Forest
Protected Area Category	/

Organisation involved	
Type of organization	Research company
Name of organisation	Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences

Methods

Authors approached radio-collared bears equipped with GPS–GSM neck collars.
Bears were approached $\leq$ 6 times per year, with $\geq$ 14 days between approaches.
Data collected on bear movements and reactions to human encounters.

Results

Encounters with people increased bear movements at night and reduced activity during the day.
No aggressive reactions from bears; 84% of approaches had no observable bear interactions.
This supports that brown bears avoid physical encounters with humans.

Gaps

Behavioral responses vary between individuals and depend on environmental factors.

References

Ordiz, A., Støen, O.-G., Saebø, S., Sahlén, V., Pedersen, B. E., Kindberg, J., & Swenson, J. E. (2013). Lasting behavioural responses of brown bears to experimental encounters with humans. Journal of Applied Ecology, 50(2), 306–314.
https://doi.org/10.1111/1365-2664.12047

Bear Behavioral Responses to Human Activity in Sweden and Finland

Jozef Limánek, Michal Kalaš, **National Park Malá Fatra**

Details on the monitoring	
Study focus	Wildlife monitoring
Type of tool / method	GPS loggers
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	More than one year
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site	
Place of monitoring	South-central Sweden Central and southeastern Finland
Country of monitoring	Sweden, Finland
Landscape type	Forest, Bog, Grassland
Protected Area Category	/

Organisation involved	
Type of organization	Research company
Name of organisation	Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences

Methods

Experimental approaches of radio-collared bears in Sweden and Finland.
Proxies for human activity included distance to roads, settlements, and human population density.
Control variables considered bear behavior, individual characteristics, season and vegetation.

Results

Bears exhibited similar flight reactions in both countries despite differences in human activity levels.
Consistency attributed to similar bear population trends, hunting practices, and species-specific responses in both countries.
Large carnivores in human-dominated landscapes tend to be elusive due to historical persecution.

Gaps

Limited geographic scope.
Limited behavioural metrics of bear behaviours and physiological indicators.
Lack of long-term effects of human disturbance on bear population.

References

Gro Kvelprud Moen, Andrés Ordiz, Kindberg, J., Swenson, J. E., Sundell, J., & Ole-Gunnar Støen. (2018). Behavioral reactions of brown bears to approaching humans in Fennoscandia. https://doi.org/10.1080/11956860.2018.1513387

Bioacoustic Monitoring with Wildlife Acoustics

Filippo Favilli, **EURAC**

Details on the monitoring	
Study focus	Wildlife monitoring
Type of tool / method	Acoustic sensor
Type of data	Acoustic data
Frequency / interval (smallest)	Continuous
Transferability to other region	☑
Dimension	Local
Development level	Established, Experimental

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	Forest, Grassland, Lake, River, Rock
Protected Area Category	/

Organisation involved	
Type of organization	Technology provider
Name of organisation	Wildlife Acoustics

Methods

Utilization of bioacoustic sensors for wildlife monitoring.
Technology provider: Wildlife Acoustics.

Results

Permanent record of animal vocalizations and other sounds.
Used mainly for monitoring bats, birds, cicadas, but also to detect presence of wolves.

Gaps

Many use cases for acoustic monitoring and new research fields evolving.
Big data management necessary.

References

Wildlifeacoustics (n.d.) Retrieved 14.09.2023
https://www.wildlifeacoustics.com/solutions/monitoring-for-species-conservation

Visitor Monitoring | Visitor Management | **Wildlife Monitoring** | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Limitations of Camera Traps in Wildlife Research

Filippo Favilli, **EURAC**

Details on the monitoring	
Study focus	Wildlife monitoring
Type of tool / method	Wildlife camera
Type of data	Optical data
Frequency / interval (smallest)	Continuous
Transferability to other region	☑
Dimension	Local
Development level	Established

Details on the monitoring site	
Place of monitoring	UK
Country of monitoring	UK
Landscape type	/
Protected Area Category	/

Organisation involved	
Type of organization	Research company
Name of organisation	Hedmark University College

Methods

Case studies addressing practical and operational issues of wildlife camera traps.
Investigation of camera models used in UK research.

Results

Monitoring of elusive species with low population density in remote areas.
Cameras require regular visits for data retrieval and battery replacement
Challenges during the study: false positive imagery, camera malfunctions, data extraction effort.

Gaps

Camera traps can generate large numbers of false positives.
Synchronizing clocks of multiple cameras is challenging.

References

Newey, S., Davidson, P., Nazir, S., Fairhurst, G., Verdicchio, F., Irvine, R. J., & van der Wal, R. (2015). Limitations of recreational camera traps for wildlife management and conservation research: A practitioner's perspective. Ambio, 44(S4), 624–635. https://doi.org/10.1007/s13280-015-0713-1

Visitor Monitoring | Visitor Management | **Wildlife Monitoring** | Vegetation Monitoring | Erosion Monitoring | Pollution Monitoring

Study of Species Richness and Structure Community of Herpetofauna on Kondang Merak Forest

Adam Varga, Linda Magyar, **CEEweb**

Details on the monitoring	
Study focus	Wildlife monitoring
Type of tool / method	Field survey
Type of data	Spatial data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Herpetofauna on Kondang Merak Forest, Malang
Country of monitoring	Indonesia
Landscape type	Forest, Beach
Protected Area Category	Nature park

Organisation involved	
Type of organization	Research company
Name of organisation	Brawijaya University, Universitas Negeri Malang

Methods

Conducted a field survey from November 2018 to June 2019 at six different site points within the Kondang Merak Forest.
Used Visual Encounter Survey (VES) with active exploration methods to document and identify encountered herpetofauna species.
Analyzed data using importance value index and the Shannon-Wiener diversity index to assess community structure.
Employed the Jaccard similarity index to group herpetofauna based on habitat similarity.

Results

Recorded a total of 38 herpetofauna species, including 8 amphibians (Anura), 15 lizards (Sauria), and 15 snakes (Serpentes) species. Found variations in species richness and diversity across different site points and habitat types.
Recorded a total of 38 herpetofauna species, including 8 amphibians (Anura), 15 lizards (Sauria), and 15 snakes (Serpentes) species. Found variations in species richness and diversity across different site points and habitat types.

Gaps

Further research is needed to investigate the specific ecological implications of these findings and develop management strategies for the conservation of herpetofauna in the Kondang Merak Forest.
The study does not discuss the potential impact of climate change, invasive species, and other environmental factors on herpetofauna populations in the region.

References

Kadafi, A. M., Fathoni, M., Fauzi, M. A., Firmansyah, R., & Kurniawan, N. (2019, August 25). Study of Species Richness and Structure Community of Herpetofauna on Kondang Merak Forest, Malang, Indonesia. https://doi.org/10.5220/0009586100890095

Trampling Effects on Coastal Vegetation in a Parabolic Dune

Ádám Varga, Linda Magyar, **CEEweb**

Details on the monitoring	
Study focus	Vegetation monitoring
Type of tool / method	Vegetation survey
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	One-time
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Coastal area of the El Farallon–La Mancha dunefield
Country of monitoring	Mexico
Landscape type	Forest, Sea
Protected Area Category	Nature Park

Organisation involved	
Type of organization	Research company
Name of organisation	Louisiana State University

Methods

Conducted a botanical survey, involving:
Vegetation analysis using quadrats along a continuous 37-meter transect.
Identification of plant species, abundance, and percent cover.
Measurement of dune axis morphology.

Results

Trampling activities led to a reduction in species richness.
Rare species were more susceptible to trampling.
Greater slope steepness resulted in a higher impact on species richness.
Steeper slopes experienced a disappearance of 40 to 80 percent of species after 100 cumulative tramplings, while low to moderate slopes saw 13 to 30 percent disappear.

Gaps

The study's sampling was limited to a single day, providing insights into short-term impacts.

References

Hesp, P., Schmutz, P., Martinez, M. M., Driskell, L., Orgera, R., Renken, K., Revelo, N. A. R., & Orocio, O. A. J. (2010). The effect on coastal vegetation of trampling on a parabolic dune. Aeolian Research, 2(2-3), 105-111.
https://doi.org/10.1016/j.aeolia.2010.03.001

Impact of Nature Tourism on Plant Diversity on Trails

Balázs Megyeri, **Bükk National Park**

Details on the monitoring	
Study focus	Vegetation monitoring
Type of tool / method	Field survey
Type of data	Alphanumerical data, Optical data
Frequency / interval (smallest)	One-time
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site	
Place of monitoring	20 nature trails in Estonia
Country of monitoring	Estonia
Landscape type	Forest, Bog
Protected Area Category	/

Organisation involved	
Type of organization	Research company
Name of organisation	Estonian University of Life Sciences, Estonia NC State University, USA

Methods

Study on plant diversity changes on nature trails.
Investigation of how nature tourism impacts vegetation along trails in different areas (wetlands, forests).

Results

Methodology revealed a significantly negative impact on vegetation diversity along the trail.
Visitor load negatively affected plant diversity regardless of habitat type or trail cover.

Gaps

Did not differentiate between alien and native species.
Tested only in wetlands and forests, lacking data for other habitat types.

References

Laanisto, L., Jaksi, P., Härm, L., Hallikma, T., Kull, T., & Leung, Y.-F. (2023). GetDiv – a call for a global coordinated study on plant diversity changes on nature trails. Journal of Ecotourism, 1–12. https://doi.org/10.1080/14724049.2023.2191894

Visitor Monitoring | Visitor Management | Wildlife Monitoring | **Vegetation Monitoring** | Erosion Monitoring | Pollution Monitoring

Citizen Science for Marine Invasive Species Monitoring

Adam Varga, Linda Magyar, **CEEweb**

Details on the monitoring	
Study focus	Vegetation monitoring
Type of tool / method	Citizen science
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	Continuous
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Egadi Islands MPA (Tyrrhenian Sea)
Country of monitoring	Italy
Landscape type	Sea
Protected Area Category	Landscape protection area

Organisation involved	
Type of organization	Park management
Name of organisation	University of Palermo

Methods

Involvement of volunteers, including students, tourists, divers, underwater photographers, amateurs, and fishermen.
Data collection included place, depth, date, substrate coverage percentage, and photos.
Scientific team validated and compiled collected data into a database.

Results

Citizen science project aimed at monitoring the spread dynamics of the sea grape Caulerpa cylindracea and other invasive algae species.
Conducted in the Egadi Islands, located 7-9 km from the western coast of Sicily.
Registered 156 sightings recorded by citizens until the project's end in 2016.

Gaps

Suggests a need for more active involvement of park managers in data collection.

References

Mannino, A. M., & Balistreri, P. (2018). Citizen science: a successful tool for monitoring invasive alien species (IAS) in Marine Protected Areas. The case study of the Egadi Islands MPA (Tyrrhenian Sea, Italy). Biodiversity, 19(1-2), 42-48. https://doi.org/10.1080/14888386.2018.1468280

Visitor Monitoring | Visitor Management | Wildlife Monitoring | **Vegetation Monitoring** | Erosion Monitoring | Pollution Monitoring

Assessing Human Trampling Impact on Alpine Swards Using Remote Sensing

Dana Sitányiová, **University of Žilina**

Details on the monitoring	
Study focus	Vegetation monitoring
Type of tool / method	Remote Sensing
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Tatry National Park
Country of monitoring	Poland
Landscape type	Forest, Rock
Protected Area Category	National park, Natura 2000

Organisation involved	
Type of organization	Research company
Name of organisation	University of Warsaw

Methods

Initial analysis of alpine sward plant communities along trails using vegetation maps.
Spectrometric measurements of selected plants with a field spectrometer.
Measurement of total chlorophyll content with a CCM-200 chlorophyll meter.
Calculation of vegetation indices based on spectral characteristics of selected species.

Results

Hyperspectral remote sensing indices confirmed varying levels of plant resistance to trampling, water stress, and PAR absorption limitations.
Statistically significant differences observed between trampled and control sites for different plant species.
Trampling damage, as detected through remote sensing methods, exhibited variations among species.

Gaps

Further studies are needed to better understand morphological and physiological changes in plants for mechanical stress (trampling).

References

Kycko, M., Zagajewski, B., Zwijacz-Kozica, M., Cierniewski, J., Romanowska, E., Orłowska, K., Ochtyra, A., & Jarocińska, A. (2017). Assessment of Hyperspectral Remote Sensing for Analyzing the Impact of Human Trampling on Alpine Swards. Mountain Research and Development, 37(1), 66. https://doi.org/10.1659/mrd-journal-d-15-00050.1

Monitoring Trampling Effects on Icelandic Plant Communities with Image Analysis

Dana Sitányiová, **University of Žilina**

Details on the monitoring	
Study focus	Vegetation monitoring
Type of tool / method	Device
Type of data	Spatial data, Alphanumerical data, Optical data
Frequency / interval (smallest)	Three years
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Þingvellir National Park Fjallabak Nature Reserve, Iceland
Country of monitoring	Iceland
Landscape type	Grassland, Rock
Protected Area Category	National park, Nature reserve

Organisation involved	
Type of organization	Research company
Name of organisation	Lund University

Methods

Evaluation of the impact of different trampling intensities on common Icelandic plant communities (grassland, moss-heath, and moss).
Utilization of digital RGB photographs to analyze and quantify vegetation in experimental plots.
Assessment of vegetation recovery rates over a three-year period.
Testing two methods for monitoring vegetation in relation to trampling, aided by multi-spectral image processing for vegetation classification.
Provision of quantitative data on vegetation condition for future comparative monitoring.

Results

High trampling intensities (200 to 500 hikers) led to significant changes in all tested plant communities (moss, moss-heath, and grassland).
Moss-heaths also exhibited significant changes under light trampling (25 to 75 hikers), with higher sensitivity in the highlands compared to lowlands.
Grassland proved to be the most resistant plant community to trampling, while moss was the least resilient.
Moss cover displayed a slow recovery rate.

Gaps

Maximum Likelihood Classification (MLC) requires time and skills to create spectral signatures for different information classes that are needed for classification algorithm.

References

Runnström, M. C., Ólafsdóttir, R., Blanke, J., & Berlin, B. (2019). Image Analysis to Monitor Experimental Trampling and Vegetation Recovery in Icelandic Plant Communities. Environments, 6(9), 99. https://doi.org/10.3390/environments6090099

Quantifying Vegetation Structure in Semi-Arid Ecosystems Using UAS and SfM Photogrammetry

Dana Sitányiová, **University of Žilina**

Details on the monitoring	
Study focus	Vegetation monitoring
Type of tool / method	Remote sensing
Type of data	Spatial data, Alphanumerical data, Optical data
Frequency / interval (smallest)	One-time
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Sevilleta National Wildlife Refuge in Central New Mexico
Country of monitoring	USA
Landscape type	Grassland, Desert
Protected Area Category	Nature reserve

Organisation involved	
Type of organization	Research company
Name of organisation	University of Exeter

Methods

Utilization of a small, unpiloted aerial system (UAS) to capture aerial photographs.
Processing of aerial photographs using structure-from-motion (SfM) photogrammetry.

Results

Creation of three-dimensional models describing vegetation structure in semi-arid ecosystems at seven sites within a grass-to-shrub transition zone.
Demonstration of how cost-effective UAS combined with SfM photogrammetry can generate ultra-fine grain biophysical data products.
Potential to revolutionize scientific understanding of ecology in ecosystems with discontinuous canopy cover, either spatially or temporally.

Gaps

To obtain expected accuracy and high-precision models this approach needed multiple overflights over study area, doubling efforts.

References

Cunliffe, A. M., Brazier, R. E., & Anderson, K. (2016). Ultra-fine grain landscape-scale quantification of dryland vegetation structure with drone-acquired structure-from-motion photogrammetry. Remote Sensing of Environment, 183, 129–143. https://doi.org/10.1016/j.rse.2016.05.019

Visitor Monitoring | Visitor Management | Wildlife Monitoring | **Vegetation Monitoring** | Erosion Monitoring | Pollution Monitoring

Monitoring Vegetation Impact from Trampling on Cadillac Mountain Summit

Balázs Megyeri, **Bükk National Park**

Details on the monitoring

Study focus	Vegetation monitoring
Type of tool / method	Remote sensing, Field survey
Type of data	Spatial data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	Local
Development level	Established/Experimental

Details on the monitoring site

Place of monitoring	Cadillac Mountain summit in Acadia National Park, Maine
Country of monitoring	USA
Landscape type	Grassland, Glacier
Protected Area Category	National park

Organisation involved

Type of organization	Research company
Name of organisation	Marshall University, Huntington University of Maine, Orono

Methods

Utilization of two multispectral high spatial resolution remote sensing datasets to quantify fractional vegetation cover changes between 2001 (IKONOS images) and 2007 (John Deere AGRI Service).
Image processing conducted using ERDAS IMAGINE 9.3 (ERDAS Inc., Norcross, GA, USA).
Field investigation performed to validate accuracy.

Results

Observed a clear spatial relationship with increased vegetation area from the core to the peripheral zone at the experimental site.
No spatial relationship found for decreasing vegetation area, with the highest decrease occurring in the peripheral zone.

Gaps

Remote sensing method is not well recognized for areas with multiple vegetation layers that disturb the discovery of impact on study sites.

References

Kim, M.-K., & Daigle, J. J. (2012). Monitoring of Vegetation Impact Due to Trampling on Cadillac Mountain Summit Using High Spatial Resolution Remote Sensing Data Sets. Environmental Management, 50(5), 956–968. https://doi.org/10.1007/s00267-012-9905-7

Visitor Monitoring | Visitor Management | Wildlife Monitoring | **Vegetation Monitoring** | **Erosion Monitoring** | Pollution Monitoring

Assessing Trampling Impacts on Hiking Trails in Iceland

Dana Sitányiová, **University of Žilina**

Details on the monitoring

Study focus	Erosion Monitoring, Vegetation Monitoring
Type of tool / method	Field survey
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	Local
Development level	Established

Details on the monitoring site

Place of monitoring	Þórsmörk and Fjallabak, Iceland
Country of monitoring	Iceland
Landscape type	Forest, Rock
Protected Area Category	Nature reserve

Organisation involved

Type of organization	Research company
Name of organisation	University of Iceland

Methods

Conducted an assessment of trampling impacts on hiking trails in Iceland.
Utilized point sampling and condition class assessment to measure trampling and the degree of deterioration.
Collected data from 817 sample points, each located at 100-meter intervals, assessing the width and depth of trails and conducting visual assessments regarding their impact on the ecosystem and severity of soil erosion.
Employed GIS for examining spatial relationships between measured trail conditions and the physical characteristics of locations.

Results

Evaluated four key indicators of trail degradation for 817 sample points:
Trail width.
Trail depth.
Ecosystem type, comparing the condition of vegetation and soil cover between trails and surrounding areas.
Visible soil erosion.

Gaps

Field observations may introduce subjectivity.
The evaluation was not correlated with tourist numbers.

References

Ólafsdóttir, R., & Runnström, M. C. (2013). Assessing hiking trails condition in two popular tourist destinations in the Icelandic highlands. Journal of Outdoor Recreation and Tourism, 3-4, 57–67. https://doi.org/10.1016/j.jort.2013.09.004

Visitor Monitoring | Visitor Management | Wildlife Monitoring | **Vegetation Monitoring** | **Erosion Monitoring** | Pollution Monitoring

Monitoring Small-Scale Habitat Fragmentation with FragMAP

Maja Pamić, **Public Institution Kamenjak**

Details on the monitoring	
Study focus	Erosion Monitoring, Vegetation Monitoring
Type of tool / method	Remote sensing
Type of data	Spatial data
Frequency / interval (smallest)	Monthly
Transferability to other region	☑
Dimension	National
Development level	Experimental
Details on the monitoring site	
Place of monitoring	Qinghai-Tibetan Plateau
Country of monitoring	China
Landscape type	Grassland
Protected Area Category	/
Organisation involved	
Type of organization	Research company
Name of organisation	State Key Laboratory of Cryospheric Sciences, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, China; School of Geographic Sciences, Nantong University, Nantong, China

Methods

FragMAP tool comprises hardware and software components.
Hardware includes a desktop computer, Huawei Pad with Android OS and GPS/GLONASS, and a DJI Phantom 3 Professional drone.
Software includes an Android application for autopilot flight, aerial photograph analysis programs, and data integration tools.

Results

FragMAP is stable, robust, efficient, and user-friendly.
Provides high-resolution aerial photographs suitable for long-term monitoring of small-scale habitat fragmentation.
Cost-effective, with a drone priced at about 1000 USD, Huawei Pad at about 300 USD, and free software.
Data integration enables reuse and cooperation within and among teams for establishing monitoring networks across diverse vegetation types and environmental conditions.

Gaps

Comparatively low-cost devices, still there remains and issue of big-data management.

References

Yi, S. (2016). FragMAP: a tool for long-term and cooperative monitoring and analysis of small-scale habitat fragmentation using an unmanned aerial vehicle. International Journal of Remote Sensing, 38(8-10), 2686–2697. https://doi.org/10.1080/01431161.2016.1253898

Visitor Monitoring | Visitor Management | Wildlife Monitoring | **Vegetation Monitoring** | **Erosion Monitoring** | Pollution Monitoring

Impacts of Trail Infrastructure on Vegetation and Soils: A Comprehensive Review

Dana Sitányiová, **University of Žilina**

Details on the monitoring	
Study focus	Vegetation monitoring, Erosion monitoring
Type of tool / method	Literature review
Type of data	Alphanumerical data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	International
Development level	Established/Experimental
Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	/
Protected Area Category	/
Organisation involved	
Type of organization	Research company
Name of organisation	Environmental Futures Research Institute, Griffith University

Methods

Utilization of systematic quantitative literature review methodology.
Assessment of the impacts of trails on vegetation and soils.
Review of 59 original research papers published in English language peer-reviewed academic journals.

Results

Geographical concentration of trail impact research in English language journals.
Most papers from IUCN category II national parks in the USA and Australia.
Disproportionate focus on trails in developed nations and specific habitats.

Gaps

Emphasis of the review on formal trails with limited comparative work and narrow spatial scale.

References

Ballantyne, M., & Pickering, C. M. (2015). The impacts of trail infrastructure on vegetation and soils: Current literature and future directions. Journal of Environmental Management, 164, 53–64. https://doi.org/10.1016/j.jenvman.2015.08.032

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | **Erosion Monitoring** | Pollution Monitoring

Report on Trail Condition Assessment and Management Implications

Alessandro Valletta, Andrea Segalini, **University of Parma**

Details on the monitoring	
Study focus	Erosion monitoring
Type of tool / method	Field survey
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Acadia National Park
Country of monitoring	USA
Landscape type	/
Protected Area Category	National park

Organisation involved	
Type of organization	Research company
Name of organisation	Virginia Tech College of Natural Resources, Department of Forest Resources & Environmental Conservation

Methods

State-of-the-art trail condition assessment and monitoring procedures were developed and applied. Protocols were created for formal and informal trail assessments. Inventory indicators:trail grade, landform grade, slope ratio, slope alignment angle, rugosity, use levels on transects. Field assessments were conducted, and data were summarized for decision-making. Guidance and training for park staff were provided.

Results

Formal Trails: Trail widening and soil loss are significant issues. Human trampling behaviour, terrain, and trail design influence trail widening. Effective management solutions include strategic placement of obstacles and visitor education. Soil loss is influenced by trail use, grade, and alignment angle. Relocations and maintenance practices can mitigate soil loss.
Informal Trails: Protocols for assessing informal trail networks were established. Acceptability of informal trails depends on factors like slope, erosion susceptibility, and impact on sensitive resources. Comprehensive guidance for managing informal trails is provided in the report.

Gaps

There is no discussion of the financial and logistical feasibility of implementing recommended management actions. Further research may be needed to assess the long-term effectiveness of management strategies.

References

Marion J.L., Wimpey J., Park L. (2011) Informal and formal trail monitoring protocols and baseline conditions: Acadia National Park. Final Report for the USDI, National Park Service - Acadia National Park. Distributed by: Virginia Tech, College of Natural Resources Department of Forest Resources & Environmental Conservation. Retrieved September 14, 2023, from https://cdn2.assets-servd.host/material-civet/production/images/documents/ACAD-Trails-Rpt-Final.pdf?dm=1657900373

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | **Erosion Monitoring** | Pollution Monitoring

Investigating Footpath Erosion in a Heathland Environment

Alessandro Valletta, Andrea Segalini, **University of Parma**

Details on the monitoring	
Study focus	Erosion monitoring
Type of tool / method	Field survey, Remote Sensing
Type of data	Spatial data
Frequency / interval (smallest)	More than one year
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Land's End, Cornwall
Country of monitoring	UK
Landscape type	Sea coast
Protected Area Category	Other

Organisation involved	
Type of organization	Research company
Name of organisation	University of Exeter

Methods

The study employed LIDAR and on-site surveys to assess soil erosion, variation in slope angles, and surface hydrology.
Aerial photogrammetry using Bluesky Maps was utilized to examine vegetation damage both on and off footpaths.

Results

The combination of these techniques revealed evidence of soil erosion occurring over a 5-year period.This erosion was accompanied by widening of footpaths and an increase in slope angles.

Gaps

The results obtained through aerial photogrammetry were deemed unsatisfactory, with potential for improvement through the use of higher-resolution data.

References

Rodway-Dyer S., Ellis N. (2018) Combining remote sensing and on-site monitoring methods to investigate footpath erosion within a popular recreational heathland environment. Journal of Environmental Management 215, 1 June 2018, Pages 68-78. https://doi.org/10.1016/j.jenvman.2018.03.030

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | **Erosion Monitoring** | Pollution Monitoring

Monitoring Human Impacts in Parks and Protected Areas Using UAVs

Alessandro Valletta, Andrea Segalini, **University of Parma**

Details on the monitoring	
Study focus	Erosion monitoring
Type of tool / method	Device, Remote Sensing
Type of data	Spatial data
Frequency / interval (smallest)	More than one year
Transferability to other region	☑
Dimension	National
Development level	Established/Experimental

Details on the monitoring site	
Place of monitoring	Jotunheimen National Park
Country of monitoring	Norway
Landscape type	/
Protected Area Category	National park

Organisation involved	
Type of organization	Research company
Name of organisation	UiT- Arctic University of Norway

Methods

The study focused on a survey area measuring 200x90 meters.
It compared manual measurements with UAV (Unmanned Aerial Vehicle) measurements, particularly examining trail width and depth.
Manual measurements were conducted along 17 transects (trail sections), while UAV data collection involved flights at an altitude of 10 meters with 70% overlap.

Results

In 2017, the study acquired 562 images, increasing to 711 in 2018, resulting in an estimated resolution of 0.5 cm per pixel.
UAV-derived information demonstrated a low error rate compared to manual surveys, indicating its reliability.

Gaps

The UAV-based data appeared to overestimate trail incision, while measurements of trail width were more dependable.
A trade-off between resolution and flight altitude was noted. This issue can be addressed by using ground-based surveys like LiDAR or conducting two flights at different altitudes.

References

Ancin-Murguzur, F.J., Munoz, L., Monz, C. and Hausner, V.H. (2020), Drones as a tool to monitor human impacts and vegetation changes in parks and protected areas. Remote Sens Ecol Conserv, 6: 105-113. https://doi.org/10.1002/rse2.127

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | **Erosion Monitoring** | Pollution Monitoring

Research on Soil Erosion Impact in Mountain Environments

Alessandro Valletta, Andrea Segalini, **University of Parma**

Details on the monitoring	
Study focus	Erosion monitoring
Type of tool / method	Device, Field survey
Type of data	Alphanumerical data
Frequency / interval (smallest)	Yearly
Transferability to other region	☑
Dimension	Local
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Ordesa and Monte Perdido National Park
Country of monitoring	Spain
Landscape type	/
Protected Area Category	Nature park

Organisation involved	
Type of organization	Research company
Name of organisation	University of Castilla–La Mancha, University of Geneva, Universidad Politécnicade Madrid, GME–Instituto Geológico y Minero de España, University of Zaragoza, Instituto Pirenaico de Ecología (CSIC)

Methods

The study focuses on assessing soil erosion impact in mountainous regions
The methods are based on dendrogeomorphology techniques.
Root profiles obtained with microtopographic profile gauges in combination with terrestrial laser scanner.
Root samples extracted to determine time of exposure (Tree species: Pinus uncinata, Fagus sylvatica).
Data is collected at multiple sites to gain a comprehensive understanding.
Findings are intended to inform the development of effective management practices.

Results

The research seeks to implement sustainable management practices in mountain environments.
Evaluation of annual erosion rates of the trail, based on the number of years since root exposure and thickness of the soil layer eroded since initial exposure.

Gaps

No information regarding trail widening provided.

References

Bodoque, J. M., Ballesteros-Cánovas, J. A., Rubiales, J. M., Perucha, M. Á., Nadal-Romero, E., and Stoffel, M. (2017) Quantifying Soil Erosion from Hiking Trail in a Protected Natural Area in the Spanish Pyrenees. Land Degrad. Develop., 28: 2255– 2267. doi: 10.1002/ldr.2755.

Assessing Soil Erosion on Mountain Trails

Alessandro Valletta, Andrea Segalini, **University of Parma**

Details on the monitoring

Study focus	Erosion monitoring
Type of tool / method	Device, Field survey, Remote sensing
Type of data	Spatial data, Alphanumerical data
Frequency / interval (smallest)	One-time
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site

Place of monitoring	Municipality of Llutxent
Country of monitoring	Spain
Landscape type	/
Protected Area Category	Other

Organisation involved

Type of organization	Research company
Name of organisation	University of Valencia

Methods

The study compared three soil erosion assessment techniques on trails:
CSA Cross-Sectional Area with manual measurements.
Aerial photogrammetry using a UAV-based camera (flight altitude: 5m).
Terrestrial photogrammetry with two smartphone cameras mounted on a wooden support.
Utilized the Structure from Motion (SfM) technique to reconstruct the trail model.

Results

Findings demonstrated strong agreement among all technologies employed.
Photogrammetry provided superior detail compared to traditional methods.

Gaps

The low flight altitude of the drone may not be suitable for vegetated areas.
The research lacks specific information about the sampling frequency.

References

Salesa, D., Amodio, A.M., Rosskopf, C.M., Garfi, V., Terol, E., Cerdà, A. (2020) Three topographical approaches to survey soil erosion on a mountain trail affected by a forest fire. Barranc de la Manesa, Llutxent, Eastern Iberian Peninsula. J. Environ. Manag. 264, 110491 https://doi.org/10.1016/j.jenvman.2020.110491.

UAV-Based Data Acquisition for Mountain Trail Erosion Assessment

Dana Sitányiová, **University of Žilina**

Details on the monitoring

Study focus	Erosion monitoring
Type of tool / method	Device, Remote sensing
Type of data	Spatial data
Frequency / interval (smallest)	/
Transferability to other region	☑
Dimension	Regional
Development level	Experimental

Details on the monitoring site

Place of monitoring	Tatry National Park
Country of monitoring	Poland
Landscape type	Forest, Rock
Protected Area Category	National park, Natura 2000

Organisation involved

Type of organization	Research company
Name of organisation	AGH University of Science and Technology

Methods

Comprehensive methodology for data acquisition in challenging mountain trail environments.
Utilization of UAV equipped with a non-metric camera.
Application of Structure from Motion (SfM) technology.

Results

Generation of point clouds, orthophotomaps, and DSMs.
Evaluation of product accuracy.
Spatial analysis of erosion in alpine areas.
Advanced spatial analyses.

Gaps

Need for additional analysis on high-resolution orthophotomaps to eliminate potential result distortions, such as increased vegetation or the presence of people during measurements.

References

Ćwiąkała, P., Kocierz, R., Puniach, E., Nędzka, M., Mamczarz, K., Niewiem, W., & Wiącek, P. (2017). Assessment of the Possibility of Using Unmanned Aerial Vehicles (UAVs) for the Documentation of Hiking Trails in Alpine Areas. Sensors, 18(2), 81. https://doi.org/10.3390/s18010081

Microplastics in Earthworm Casts and Surrounding Soil

Maja Pamić, **Public Institution Kamenjak**

Details on the monitoring	
Study focus	Pollution monitoring
Type of tool / method	Field survey
Type of data	Alphanumerical data
Frequency / interval (smallest)	One-time
Transferability to other region	☑
Dimension	National
Development level	/

Details on the monitoring site	
Place of monitoring	20 sampling locations - agricultural fields and urban parks
Country of monitoring	Croatia
Landscape type	Agricultural fields and urban parks
Protected Area Category	/

Organisation involved	
Type of organization	Research company
Name of organisation	University of Osijek

Methods

Examined the biodegradation of microplastics in soil by earthworms through ingestion. Analyzed the count and size of microplastics in earthworm casts and soil samples. Sample preparation includes drying, homogenization, and weighing. Density separation through digestion of organic matter using 30% H2O2 at 60°C. Mixing environmental sample with 5M aqueous ZnCl2 solution followed by a 2-hour sedimentation period. Separation of microplastics floating at the top of the solution. Supernatant containing microplastics is decanted and filtered. Dried filters are inspected under a stereo microscope.
Individual microplastic particles are separated with tweezers, placed on a microscope slide next to a millimeter paper, and photographed using a digital microscope camera. Images are analyzed using ImageJ 1.5 software.

Results

Contrary to expectations, the count of microplastics in earthworm casts was lower than in soil samples.
The microplastics found in earthworm casts were larger in size compared to those in soil.
These findings suggest a potential preferential retention of smaller microplastics within earthworms, which may lead to bioaccumulation.

Gaps

The study does not provide a detailed explanation for the unexpected results, leaving room for further research to understand the mechanisms behind microplastic retention by earthworms.

References

Ćaleta, Bruno & Hackenberger, Davorka & Hackenberger, Branimir. (2022). Microplastics in Lumbricus terrestris middens/casts and surrounding urban soil.

Monitoring Marine Litter in Mediterranean MPAs: The Plastic Busters Approach

Maja Pamić, **Public Institution Kamenjak**

Details on the monitoring	
Study focus	Pollution monitoring
Type of tool / method	Field survey
Type of data	Alphanumerical data
Frequency / interval (smallest)	Monthly
Transferability to other region	☑
Dimension	International
Development level	Established

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	/
Landscape type	/
Protected Area Category	/

Organisation involved	
Type of organization	Research company
Name of organisation	INTERREG Med Plastic Busters MPAs project

Methods

Manual collection of macroplastic on a 100-meter beach transect.
Classification of items found on the sampling unit according to the Joint List of Marine Litter Items Categories, in collaboration with EU Member States and Regional Sea Conventions.
Utilization of a manual with detailed information on litter item classification and a photo guide to aid surveyors in identification and categorization.
Litter items can be classified and recorded on-site or in a lab after sampling.
Suggested at least 4 surveys (January, April, July, October).
Removal of all litter items from the sampling unit during the survey.

Results

Classification and quantification of litter items based on the Joint List of Marine Litter Items Categories.

Gaps

Some site selection characteristics can not be applicable to all beaches.

References

Fossi M.C, Vlachogianni, T., Anastasopoulou, A., Alomar, C., Baini, M., Caliani, I., Consoli, P., Deudero, S., Galgani, F., Kaberi H., Panti, C., Romeo, T., Tsangaris, C., Zeri, C. (2022). Monitoring the presence and effects of marine litter in Mediterranean MPAs: the Plastic Busters MPAs approach. Interreg Med Plastic Busters MPAs project (D.5.2.1).

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | **Pollution Monitoring**

Marine Litter Monitoring on Beaches: Guidelines and Methodology

Maja Pamić, **Public Institution Kamenjak**

Details on the monitoring	
Study focus	Pollution monitoring
Type of tool / method	Field survey
Type of data	Alphanumerical data
Frequency / interval (smallest)	Monthly
Transferability to other region	☑
Dimension	International
Development level	Established

Details on the monitoring site	
Place of monitoring	/
Country of monitoring	UK
Landscape type	Beach
Protected Area Category	/

Organisation involved	
Type of organization	Association
Name of organisation	University of Osijek

Methods

Conduct beach surveys four times a year.
Removal of all litter items from the beach during the survey.
Data entry on the survey form while collecting litter.
Identification and quantification of litter items.

Results

Identification and quantification of various litter categories found on beaches, including plastic, glass, cloth, rubber, paper, wood, metal, pottery, medical and sanitary waste, and waxes.

Gaps

Ideal beach criteria include being composed of sand or gravel, exposed to the open sea, accessible year-round to surveyors, easily accessible for marine litter removal, minimum length of 100 meters (preferably over 1 km), free of buildings year-round, and not subject to other litter collection activities. However, not all beaches meet these criteria.

References

Wenneker, B.; Oosterbaan, L. and Intersessional Correspondence Group on Marine Litter (ICGML) (2010) Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area. Edition 1.0. London, UK, OSPAR Commission, 15pp. & Annexes. DOI: http://dx.doi.org/10.25607/OBP-968

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | **Pollution Monitoring**

Beach Macro-Litter Monitoring on Southern Baltic Beaches

Maja Pamić, **Public Institution Kamenjak**

Details on the monitoring	
Study focus	Pollution monitoring
Type of tool / method	Field survey
Type of data	Alphanumerical data
Frequency / interval (smallest)	Monthly
Transferability to other region	☑
Dimension	International
Development level	Established

Details on the monitoring site	
Place of monitoring	35 beaches along the German and Lithuanian Baltic coast
Country of monitoring	Germany, Lithuania
Landscape type	Beach
Protected Area Category	/

Organisation involved	
Type of organization	Research company
Name of organisation	Leibniz Institute for Baltic Sea Research

Methods

Implementation of OSPAR methodology conducted four times a year on 35 beaches along the German and Lithuanian Baltic coast over 2–5 years.
Additional experiments addressing the subjectivity of field surveys and spatio-temporal variability on different scales.

Results

Findings indicate a limited number of suitable beaches (without regular cleaning).
Tourism/recreation is the dominant source of litter on all beaches, leading to strong small-scale pollution gradients.
High temporal and spatial variability in item abundances characterizes the situation on the German Baltic coast.
Concludes that the macro-litter beach monitoring method is less suitable for the Baltic region compared to the North Sea/Atlantic region.
Suggests that it can only serve as a complementary method in combination with others, except for exceptions like Lithuania.

Gaps

Intensively used beaches for recreational purposes are likely to exhibit the highest pollution levels but are not suitable for official MSFD-monitoring due to beach cleanings.

References

Schernewski, G., Balciunas, A., Gräwe, D., Gräwe, U., Klesse, K., Schulz, M., Wesnigk, S., Fleet, D., Haseler, M., Möllman, N., & Werner, S. (2017). Beach macro-litter monitoring on southern Baltic beaches: results, experiences and recommendations. Journal of Coastal Conservation, 22(1), 5–25. https://doi.org/10.1007/s11852-016-0489-x

Visitor Monitoring | Visitor Management | Wildlife Monitoring | Vegetation Monitoring | Erosion Monitoring | **Pollution Monitoring**

Microplastics in Swiss Floodplain Soils

Maja Pamić, **Public Institution Kamenjak**

Details on the monitoring	
Study focus	Pollution monitoring
Type of tool / method	Field survey
Type of data	Alphanumerical data
Frequency / interval (smallest)	One-time
Transferability to other region	☑
Dimension	National
Development level	Experimental

Details on the monitoring site	
Place of monitoring	Switzerland
Country of monitoring	Switzerland
Landscape type	River
Protected Area Category	Nature reserve

Organisation involved	
Type of organization	Research company
Name of organisation	Institute of Geography, University of Bern

Methods

Microplastics (MPs) in soil samples were separated from the mineral fraction through density-based techniques.
Tests were conducted using NaCl (1.2 g cm-3) and CaCl2 (1.5 g cm-3) solutions.
Four different methods for separating mineral particles from the supernatant were tested.

Results

Four different density separation methods were evaluated: separation cylinder, self-constructed MP separator, centrifugation, and centrifugation with a rubber disc inserted post-centrifugation to prevent resuspension of mineral particles.
MP recoveries using these methods ranged between 93-98% and were not significantly different.
The centrifuge method was notably faster than the other methods, and the rubber disc prevented mineral particle resuspension.
Various chemicals for removing organic material were tested, with HNO3 proving most effective.
HNO3 treatment caused ABS, PA, and PET particles to decompose or disintegrate into smaller particles, though these materials were not found in the large MP fractions.

Gaps

While the method efficiently extracts, identifies, and quantifies most MPs in organic-matter-rich soil in a time- and cost-effective manner, it has limitations when analyzing ABS, PA, PET, and PVC in the small MP range due to their high density or disintegration during organic matter oxidation.

References

Scheurer, M., & Bigalke, M. (2018). Microplastics in Swiss Floodplain Soils. Environmental Science & Technology, 52(6), 3591–3598. https://doi.org/10.1021/acs.est.7b06003

4. Outlook

This report serves as a comprehensive compilation of good-practice examples related to monitoring across various study focuses, including visitor engagement, wildlife observation, vegetation assessment, as well as erosion monitoring and pollution monitoring. These examples are presented in two distinct formats: summaries derived from the **HUMANITA** workshop and factsheets resulting from the collective desk research efforts of the entire project consortium. Together, they offer an expansive overview of monitoring within the aforementioned domains.

The primary objective of this report is to provide a consolidated document containing comprehensive information on monitoring practices. This knowledge resource is intended for use by PA managers and researchers, offering valuable insights to aid in the planning of their own monitoring initiatives. The inclusion of methods and references facilitates further exploration and understanding of this field.

Each good-practice example is structured into several key components, with a focus on methods, results, and gaps. These sections provide readers a quick overview of the presented research, helping them assess the example's relevance. It is noteworthy that the "gaps" section is of particular importance when planning future monitoring endeavours, as it summarizes potential pitfalls and challenges that should be considered. Addressing these gaps can contribute to the generation of more robust and reliable results.

It is important to clarify that this report does not aim to comprehensively cover all published literature pertaining to the presented study focuses. Instead, it offers a curated collection of selected good-practice examples employed within the **HUMANITA project**, serving as a valuable resource for those involved in monitoring activities.

The good practice workshop can be found under the following link on the **YouTube channel** (@Humanita_EU_2023): **www.youtube.com/watch?v=g3p5oHqBSYA**

Acknowledgements:

Report on good-practice to monitor environmental impact of tourism inside protected areas is developed within the **INTERREG Central Europe project "HUMANITA – Human-Nature Interactions and Impacts of Tourist Activities on Protected Areas"**. It is supported by the **Interreg CENTRAL EUROPE Programme 2021-2027** with co-financing from the **European Regional Development Fund (ERDF)** – the project total budget is 2.396.346,70 EUR, of which the ERDF funding amounts to 1.917.077,36 EUR.

References

Ancin-murguzur, F. J., & Munoz, L. (2020). Drones as a tool to monitor human impacts and vegetation changes in parks and protected areas Drones as a tool to monitor human impacts and vegetation changes in parks and protected areas. September 2019. **https://doi.org/10.1002/rse2.127**

Ballantyne, M., & Pickering, C. M. (2015). The impacts of trail infrastructure on vegetation and soils: Current literature and future directions. Journal of Environmental Management, 164, 53–64. **https://doi.org/10.1016/j.jenvman.2015.08.032**

Bielański, M., Taczanowska, K., Muhar, A., Adamski, P., González, L.-M., & Witkowski, Z. (2018). Application of GPS tracking for monitoring spatially unconstrained outdoor recreational activities in protected areas-A case study of ski touring in the Tatra National Park, Poland. **https://doi.org/10.1016/j.apgeog.2018.05.008**

Bodoque, J. M., Ballesteros-Cánovas, J. A., Rubiales, J. M., Perucha, M. Á., Nadal-Romero, E., & Stoffel, M. (2017). Quantifying Soil Erosion from Hiking Trail in a Protected Natural Area in the Spanish Pyrenees. Land Degradation and Development, 28(7), 2255–2267. **https://doi.org/10.1002/ldr.2755**

Candrea, A. N., & Ispas, A. (2009). Visitor Management , a Tool for Sustainable Tourism Development in Protected Areas. Bulletin of the Transilvania University of Braşov, 2(51), 131–136. **http://but.unitbv.ro/BU2009/BULETIN2009/Series V/BULETIN V PDF/131 Candrea Ispas BUT 2009.pdf**

Canteiro, M., Córdova-Tapia, F., & Brazeiro, A. (2018). Tourism impact assessment: A tool to evaluate the environmental impacts of touristic activities in Natural Protected Areas. Tourism Management Perspectives, 28(September), 220–227. **https://doi.org/10.1016/j.tmp.2018.09.007**

Cretois, B., Rosten, C. M., & Sethi, S. S. (2022). Voice activity detection in eco-acoustic data enables privacy protection and is a proxy for human disturbance. Methods in Ecology and Evolution, 13(12), 2865–2874. **https://doi.org/10.1111/2041-210X.14005**

Ćwiąkała, P., Kocierz, R., Puniach, E., Nędzka, M., Mamczarz, K., Niewiem, W., & Wiącek, P. (2018). Assessment of the possibility of using Unmanned Aerial Vehicles (UAVs) for the documentation of hiking trails in alpine areas. Sensors (Switzerland), 18(1). **https://doi.org/10.3390/s18010081**

Davorka, K. (2022). Microplastics in Lumbricus terrestris middens / casts and surrounding urban soil. July.

Digitize the Planet, official website, Digitize the Planet e.V. (access: 5.09.2023)

Fortin, J. K., Rode, K. D., Hilderbrand, G. V., Wilder, J., Farley, S., Jorgensen, C., & Marcot, B. G. (2016). Impacts of human recreation on brown bears (Ursus arctos): A review and new management tool. PLoS ONE, 11(1), 1–26. **https://doi.org/10.1371/journal.pone.0141983**

Fossi M.C, Vlachogianni, T., Anastasopoulou, A., Alomar, C., Baini, M., Caliani, I., Consoli, P., Deudero, S., Galgani, F., Kaberi H., Panti, C., Romeo, T., Tsangaris, C., Zeri, C. (2022). Monitoring the presence and effects of marine litter in Mediterranean MPAs: the Plastic Busters MPAs approach.

Graf, R. F., Signer, C., Reifler-Bächtiger, M., Wyttenbach, M., Sigrist, B., & Rupf, R. (2018). Wildlife and humans in outdoor recreational areas near cities. Wildtier Und Mensch Im Naherholungsraum, 13(2), 8.

Grassini, L., & Dugheri, G. (2021). Mobile phone data and tourism statistics: a broken promise? National Accounting Review, 3(1), 50–68. **https://doi.org/10.3934/nar.2021002**

Horst, L., Taczanowska, K., Porst, F., & Arnberger, A. (2023). Evaluation of GNSS-based Volunteered Geographic Information for assessing visitor spatial distribution within protected areas: A case study of the Bavarian Forest National Park, Germany. Applied Geography, 150(November 2022), 102825. **https://doi.org/10.1016/j.apgeog.2022.102825**

Kadafi, A. M., Fathoni, M., Fauzi, M. A., Firmansyah, R., Priambodo, B., & Kurniawan, N. (2020). Study of Species Richness and Structure Community of Herpetofauna on Kondang Merak Forest, Malang, Indonesia. January, 89–95. **https://doi.org/10.5220/0009586100890095**

KC, B. (2022). Complexity in balancing conservation and tourism in protected areas: Contemporary issues and beyond. Tourism and Hospitality Research, 22(2), 241–246. **https://doi.org/10.1177/14673584211015807**

Kycko, M., Zagajewski, B., Zwijacz-Kozica, M., Cierniewski, J., Romanowska, E., Orłowska, K., Ochtyra, A., & Jarocińska, A. (2017). Assessment of Hyperspectral Remote Sensing for Analyzing the Impact of Human Trampling on Alpine Swards. Mountain Research and Development, 37(1), 66–74. **https://doi.org/10.1659/MRD-JOURNAL-D-15-00050.1**

Leung, Y., Spenceley, A., Hvenegaard, G., Buckley, R., & Groves, C. (2018). Tourism and visitor management in protected areas: guidelines for sustainability. In Tourism and visitor management in protected areas: guidelines for sustainability (Issue 27). IUCN, International Union for Conservation of Nature. **https://doi.org/10.2305/iucn.ch.2018.pag.27.en**

Mason, P. (2005). Visitor management in protected areas: From "hard" to "soft" approaches? Current Issues in Tourism, 8(2–3), 181–194. **https://doi.org/10.1080/13683500508668213**

Moena, G. K., Ordiz, A., Kindberg, J., Swenson, J. E., Sundell, J., & Støen, O. G. (2019). Behavioral Reactions of Brown Bears to Approaching Humans in Fennoscandia. Ecoscience, 26(1), 23–33. **https://doi.org/10.1080/11956860.2018.1513387**

Muhar, A., Arnberger, A., & Brandenburg, C. (2002). Methods for Visitor Monitoring in Recreational and Protected Areas: An Overview. Monitoring and Management of Visitor Flows in Recreational and Protected Areas, 1–6.

Newey, S., Davidson, P., Nazir, S., Fairhurst, G., Verdicchio, F., Irvine, R. J., & van der Wal, R. (2015). Limitations of recreational camera traps for wildlife management and conservation research: A practitioner's perspective. Ambio, 44, 624–635. **https://doi.org/10.1007/s13280-015-0713-1**

Opačić, V. T., & Koderman, M. (2020). Explanatory notes on tourism in protected areas of Croatia and Slovenia. Challenges of Tourism Development in Protected Areas of Croatia and Slovenia, November, 9–25. **https://doi.org/10.26493/978-961-7055-08-5.9-25**

OSPAR. (2010). Guideline for monitoring marine litter on the beachs in the OSPAR Maritime Area. OSPAR Commission, 1, 84.

Oviedo-García, M. Á., Vega-Vázquez, M., Castellanos-Verdugo, M., & Orgaz-Agüera, F. (2019). Tourism in protected areas and the impact of servicescape on tourist satisfaction, key in sustainability. Journal of Destination Marketing and Management, 12(February), 74–83. **https://doi.org/10.1016/j.jdmm.2019.02.005**

Pescott, O. L., & Stewart, G. B. (2014). Assessing the impact of human trampling on vegetation: A systematic review and meta-analysis of experimental evidence. PeerJ, 2014(1), 1–20. **https://doi.org/10.7717/peerj.360**

Pickering, C. M., & Hill, W. (2007). Impacts of recreation and tourism on plant biodiversity and vegetation in protected areas in Australia. Journal of Environmental Management, 85(4), 791–800. **https://doi.org/10.1016/j.jenvman.2006.11.021**

Reif, J., & Schmücker, D. (2020). Exploring new ways of visitor tracking using big data sources: Opportunities and limits of passive mobile data for tourism. Journal of Destination Marketing and Management, 18. **https://doi.org/10.1016/j.jdmm.2020.100481**

Rodway-Dyer, S., & Ellis, N. (2018). Combining remote sensing and on-site monitoring methods to investigate footpath erosion within a popular recreational heathland environment. Journal of Environmental Management, 215, 68–78. **https://doi.org/10.1016/j.jenvman.2018.03.030**

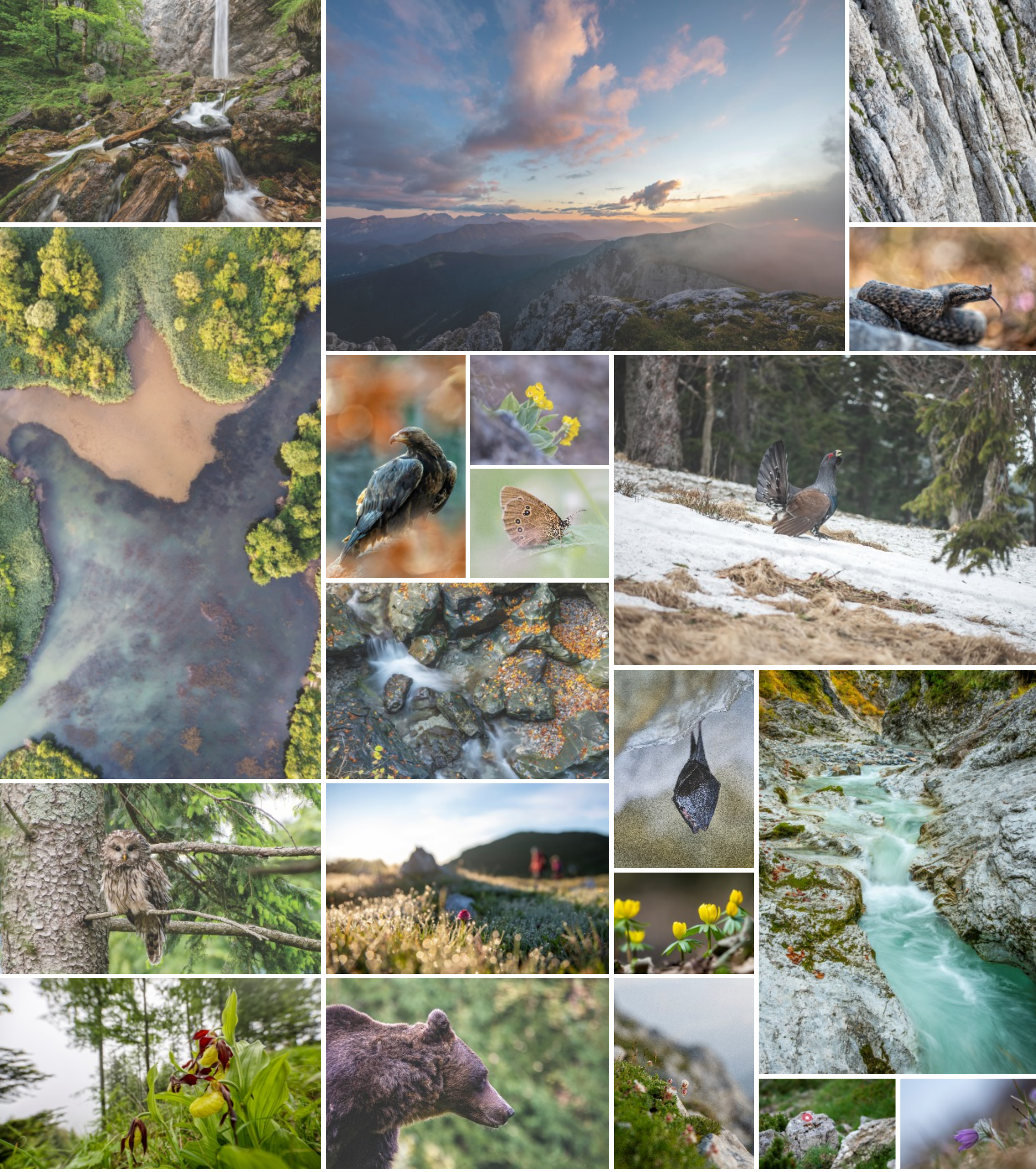
Schulze, K., Knights, K., Coad, L., Geldmann, J., Leverington, F., Eassom, A., Marr, M., Butchart, S. H. M., Hockings, M., & Burgess, N. D. (2018). An assessment of threats to terrestrial protected areas. Conservation Letters, 11(3), 1–10. **https://doi.org/10.1111/conl.12435**

Štrba, L., Kolačkovská, J., Kršák, B., Sidor, C., & Lukáč, M. (2022). Perception of the Impacts of Tourism by the Administrations of Protected Areas and Sustainable Tourism (Un)Development in Slovakia. Sustainability (Switzerland), 14(11). **https://doi.org/10.3390/su14116696**

Taczanowska, K., Bielański, M., González, L. M., Garcia-Massó, X., & Toca-Herrera, J. L. (2017). Analyzing spatial behavior of backcountry skiers in mountain protected areas combining GPS tracking and graph theory. Symmetry, 9(12), 1–15. **https://doi.org/10.3390/sym9120317**

Taczanowska, K., González, L. M., Garcia-Massó, X., Muhar, A., Brandenburg, C., & Toca-Herrera, J. L. (2014). Evaluating the structure and use of hiking trails in recreational areas using a mixed GPS tracking and graph theory approach. Applied Geography, 55, 184–192. **https://doi.org/10.1016/j.apgeog.2014.09.011**

Wyttenbach, M., Signer, C., Sigrist, B., Graf, R. F., & Rupf, R. (2016). Mountainbiking and wildlife – disturbance experiments with roe deer (Capreolus capreolus) in Switzerland. Monitoring and Management of Visitors in Recreational and Protected Areas, October, 444–447. **https://www.researchgate.net/publication/308937356**



UNIVERSITY OF ŽILINA

GEOPARK KARAWANKEN KARAVANKE

unesco Global Geopark

eurac research

KÄRNTEN UNESCO Chair on Sustainable Management of Conservation Areas

unesco Chair

NOTITIA savjetovanje & usluge

NÁRODNÝ PARK MALÁ FATRA

UNIVERSITÀ DI PARMA

Bükki Nemzeti Park Igazgatóság

CEEweb for Biodiversity

Kamenjak JAVNA USTANOVA KAMENJAK

Parco Nazionale APPENNINO TOSCO-EMILIANO