Digital Management and Monitoring Technologies in Alpine Protected Areas

Report

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Abbreviations:

APAs = Alpine Protected Areas

1 Context, Objectives and Approach

The use of digital technologies becomes increasingly important in all different areas of park management and monitoring. This report is set out to help staff from Alpine protected areas (APAs) review existing technologies, map common challenges, and promote future collaboration on digital tool implementation with other APAs. It is based on results from **a survey** conducted by ALPARC, asking questions on tool implementation in three areas: **1) biodiversity monitoring and management, 2) visitor information, guidance and management**, as well as **3) other key missions of APAs**. It further includes items asking about challenges that parks encounter regarding digital tool implementation, their view on tool efficiency, current collaborations with applications, organisations and other parks, as well as their plans and ambitions.

Apart from the survey, this report also makes use of extensive internet research on digital tools used in all National Parks and **three in-depth interviews** with park's staff.

The conclusions drawn from this report will also contribute to two Interreg Alpine Space projects in which ALPARC is currently involved**, AlpsLife and LiveAlpsNature**. AlpsLife addresses the issue of biodiversity monitoring, with the aim of making existing monitoring schemes of APAs comparable and of enhancing protection measures across borders. LiveAlpsNature, that explores the interrelation between conservation and visitor management, proposes innovative solutions for nature-based activities that are more biodiversity aware. While digital tools will be an integral part of both projects, LiveAlpsNature specifically focuses on their employment for visitor information and guidance.

Survey Participants (Parks)

In total, **30 parks participated** in the survey (September to October 2024)**.** Among them are 10 National Parks[1], 11 Nature Parks, 3 Nature Reserves, 1 UNESCO World Heritage Site, 1 UNESCO Biosphere, 1 Wildlife Park and 1 protected area management authority[2]. From the 30 participants, 9 were from Austria, 8 from Italy, 7 from Switzerland, 4 from France, 1 from Slovenia and 1 from Germany (Figure 1).

You can find all survey participants and their contact E-Mail addresses in Table 1.

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[1] Three unique responses were received from the Hohe Tauern National Park (Carinthia, Salzburg and Tyrol)
[2] The Ente di gestione delle Aree Protette delle Alpi Marittime manages two Nature Parks (Parco Naturale Alpi Marittime and Parco Naturale del Marguareis) and eight Nature Reserves.
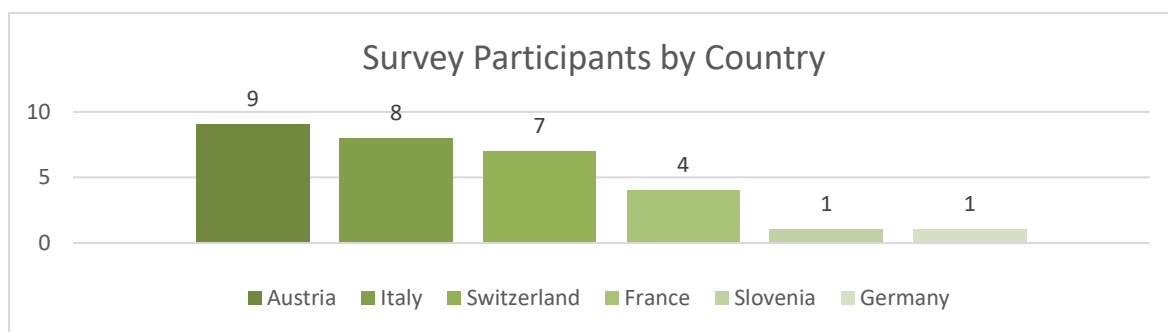
Figure 1: Alpine Protected Areas participating in the survey, by country

Country	Name / Category	Contact
Italy	Nature Park Prealpi Giulie	stefano.santi@parcoprealpigiulie.it
Italy	Nature Park Dolomiti Friulane	direzione@parcodolomitifriulane.it
Italy	National Park Stelvio	luca.pedrotti@ersaf.lombardia.it
Italy	Nature Park Mont Avic	info@montavic.it
Italy	Nature Park Adamello Brenta	andrea.mustoni@pnab.it
Italy	Ente di gestione delle Aree Protette delle Alpi Marittime	livio.giraudo@areeprotettealpimarittime.it
Italy	National Park Dolomiti Bellunesi	e.vettorazzo@dolomitipark.it
Italy	Nature Reserve Orobie Valtellinesi	natura@parcorobievalt.com
France	Nature Park Verdon	jpgallet@parcduverdon.fr
France	National Natural Reserve of Haute-Savoie	jules.grillot@cen-haute-savoie.org
France	National Park Vanoise	samuel.cado@vanoise-parcnational.fr
France	National Park Ecrins	camille.monchicourt@ecrins-parcnational.fr
Austria	Nature Park Mürzer Oberland	andreas.steininger@muerzeroberland.at
Austria	Nature Park Weißbach	info@naturpark-weissbach.at
Austria	Nature Park Dobratsch and Weißensee	robert.heuberger@ktn.gv.at
Austria	Nature Park Karwendel	anton.heufelder@karwendel.org
Austria	National Park Hohe Tauern Carinthia	katharina.aichhorn@ktn.gv.at
Austria	National Park Hohe Tauern NP Tyrol	florian.jurgeit@tirol.gv.at
Austria	National Park Hohe Tauern Salzburg	nationalpark@salzburg.gv.at
Austria	National Park Gesäuse	h.woelger@nationalpark-gesaeuse.at
Austria	National Park Kalkalpen	josef.forstinger@kalkalpen.at
Switzerland	UNESCO Biosphäre Entlebuch	f.knaus@biosphaere.ch
Switzerland	Nature Reserve Beverin	michael.forster@naturpark-beverin.ch
Switzerland	Swiss National Park	info@nationalpark.ch
Switzerland	Wildlife Park Zürich	ronald.schmidt@wildnispark.ch
Switzerland	UNESCO Swiss Alps Jungfrau-Aletsch	h.leiggener@jungfraualetsch.ch
Switzerland	Nature Park Pfyn-Finges	p.oggier@pfyn-finges.ch
Switzerland	Nature Park Beverin	fabian.freuler@naturpark-beverin.ch
Slovenia	National Park Triglav	andrej.arih@tnp.gov.si
Germany	National Park Berchtesgaden	sarah.wendl@npv-bgd.bayern.de

Table 1: Alpine Protected Areas participating in the survey

2 Biodiversity Management and Monitoring

The first block of the survey asked participants what kind of tools are in use in their parks. Figure 2 displays all the answers from the survey. We can see that **almost all the participating parks (29 of 30) use data management software** at least to some extent for their biodiversity data management. Many specify using 'GIS'. Some of the Austrian parks further specify being part of ‘parcs.at’, an Austrian data management network. National Park Gesäuse uses a software and database called "BioOffice", which can be used mobile and offline, while Wildlife Park Zürich has its own GIS-department.

Picture 1: Audiologger ©Nationalpark Berchtesgaden

Also, the vast **majority of parks use camera traps** (25) for monitoring purposes, often for specific species' monitoring, like lynx. The same goes for **sensors** (21), ranging from temperature, over audio loggers, to meteorological sensors. 18 parks make use of **GPS-tracking**, often through GPS-collars on endangered species. Also, 17 parks use **remote sensing tools**, like drones and satellites. Nature Park Beverin further makes use of drones for visitor monitoring, while National Park Kalkalpen uses Airbone Laserscanning technologies.
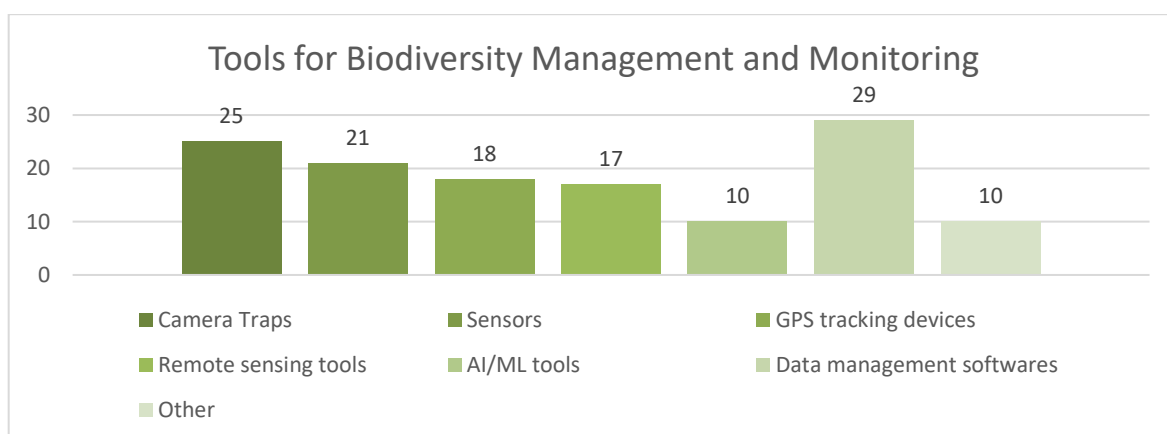

Figure 2: Biodiversity Monitoring and Management tools

As can be seen in Figure 2, **fewer parks** make use of **Artificial Intelligence/Machine Learning (AI/ML) tools** (10). Among those who do, National Park Gesäuse uses them for automated image and sound recognition but also DNA sampling and the Nature Park Verdon uses them for the analysis of land

coverage and usage. Other tools indicated by the parks include tablets for plant monitoring (National Park Triglav), night vision tools (Aree Protette delle Alpi Marittime) and data capturing tools (field maps) (Swiss National Park).

In the open comment options of the survey, it already becomes clear that many of the parks outsource these services to external service providers. The survey includes one item at the end, asking specifically about this. The answers to this item are displayed in Figure 3.
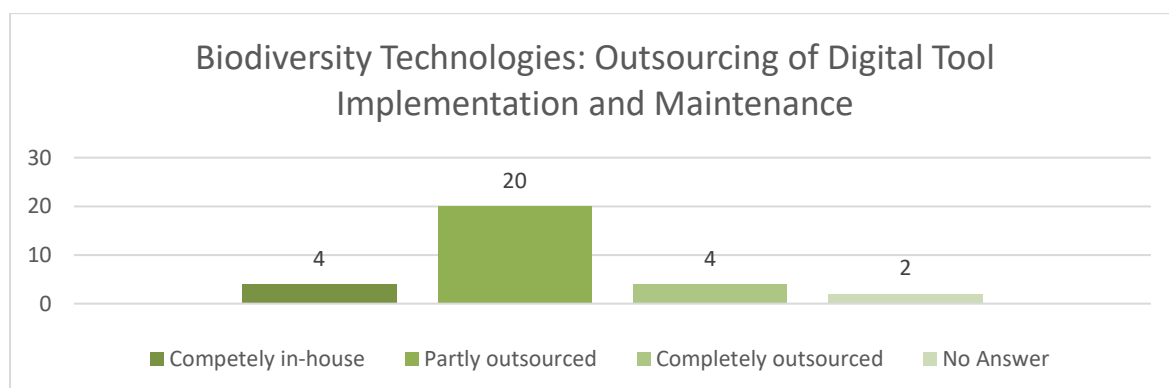

Figure 3: Outsourcing of digital tool implementation and maintenance in biodiversity monitoring and management

We can see that the **large majority** of parks **partly outsources** the implementation and maintenance of the digital tools they use for biodiversity monitoring and management. Among National Parks, most outsource these services to at least some extent, with the National Park Vanoise indicating complete reliance on and the National Park Ecrins complete independence of external service providers.

Parks face **challenges** with digital technologies for biodiversity monitoring and management mostly due to **budget constraints** (see Figure 4). **Data management issues, technical limitations and insufficient knowledge** of the existent tools, however, also pose significant challenges to implementation and maintenance. Multiple parks further name **staff and training limitations** as one of the most important challenges (9 participants), but also **time constraints** (4), the lack of **mobile reception** in protected areas (3) and **data storage difficulties** (2).
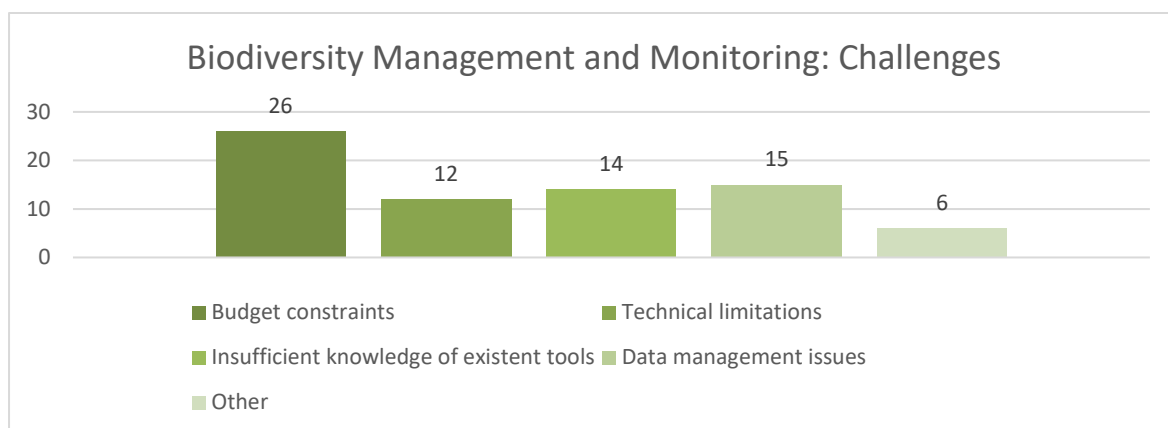
Figure 4: Challenges related to the implementation of digital tools in biodiversity monitoring and management

Moreover, the survey included an item asking about the general efficiency of the digital technologies used for biodiversity monitoring and management purposes (Figure 5). **Most participants rate** their digital tools in use **as rather efficient**, with a 4 out of 5 rating. Two parks seem dissatisfied with their digital tools in place, while three are neutral and five very content with their success in achieving biodiversity monitoring and management goals. In comparison to others, National Parks are more content with the performance of their digital tools in place on average.
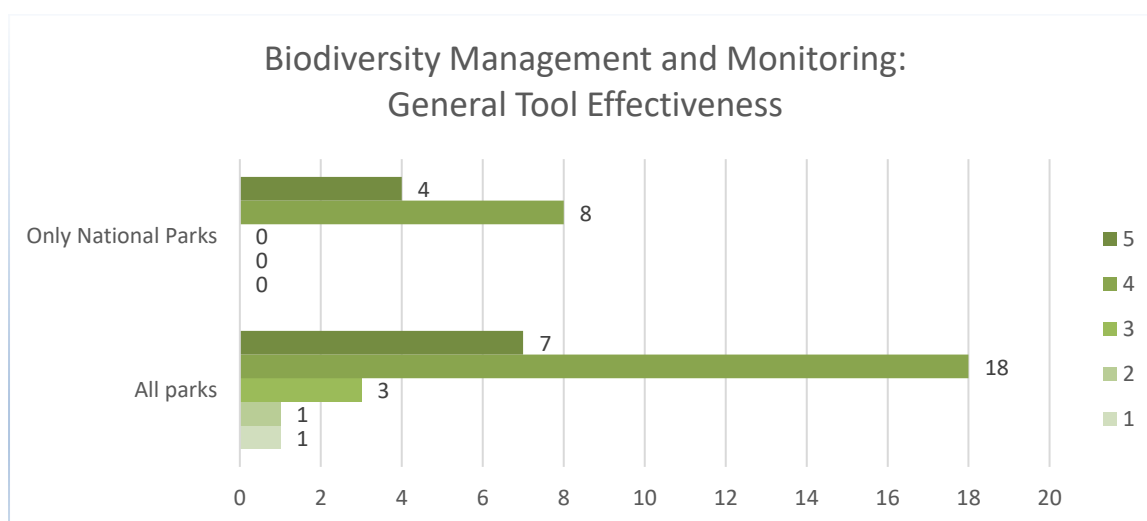

Figure 5: Effectiveness pf digital tools to achieve biodiversity monitoring and management goals

In every thematic block of the survey, the participants had the chance to name some particularly specific tools in usage. The UNESCO Biosphere Entlebuch has a set of water table measuring devices used to monitor peatland (raised bogs) integrity over the next decades. The Ente di gestione delle Aree Protette delle Alpi Marittime uses and recommends the application 'Deep Faune' for analyzing and archiving photo-trap images. Since 2021, the National Park Berchtesgaden performs permanent biodiversity monitoring on 54 different plots with different measurement tools and devices. Also, they

have their own app for bark beetle management and wildlife regulation. Lastly, The Mont Avic Natural Park uses sound recorders to monitor rock ptarmigan and software to isolate their calls. Also, they use a drone with software to create a 3D model of wetlands monitoring changes in dimension or vegetation.

3 Visitor Information, Guidance and Management

The second block of the survey asks about the tools used for visitor information, guidance and management. Figure 6 shows the survey responses to the question about the tools currently in place at the parks. The tools that are **most common** are **online booking options and visitor counting stations,** with **22 parks** using them. Online booking options range from cultural activities, over guided tours, to transportation and accommodation. Interestingly, **only around a third**

Picture 2: Nature Park Karwendel ©Lanzanasto

(10) use digital visitor feedback options. Regarding visitor counters, two parks make use of 'Eco-Counter' and two parks (National Park Hohe Tauern Tyrol; Nature Park Beverin) indicate using AI/ML technologies to support the counters. Apart from these two, only the Swiss National Park uses AI/ML tools in the field of visitor information and management so far. Also**, 19 parks use mobile apps**, however, through the comment section it becomes clear that not all of them have their own park-apps but use or collaborate with e.g., applications like 'Strava'. Four parks also mention the use of **apps through which visitors can enter species observations**: Nature Park Verdon uses 'GeoNature Citizen', which was created by French National Parks, the Nature Park Adamello Brenta makes use of 'iNaturalist', while the Nature Park Pfyn-Finges and the National Park Hohe Tauern Carinthia use 'Observation.org'.

20 parks provide some sort of interactive maps and 14 tour planning tools for their visitors. Multiple **parks collaborate with online platforms such as 'Komoot', 'Outdooractive', 'Contwise' or 'Geotrek'. Very few parks so far have tour gamification tools**. Among those, the National Park Berchtesgaden uses the App 'Actionbound', National Park Hohe Tauern Salzburg uses 'Earthcache', the Nature Park Adamello Brenta uses the App 'Impronto' for Geocaching, and the Nature Park Karwendel collaborates with multiple tourist organizations. Finally, 12 parks provide real-time webcams images/recordings to their visitors, while 8 give real-time weather reports. As other digital tools, the Nature Park Prealpi

Giulie and the National Park Gesäuse indicate **mobile phone data tracking.**

Tools for Visitor Information and Management

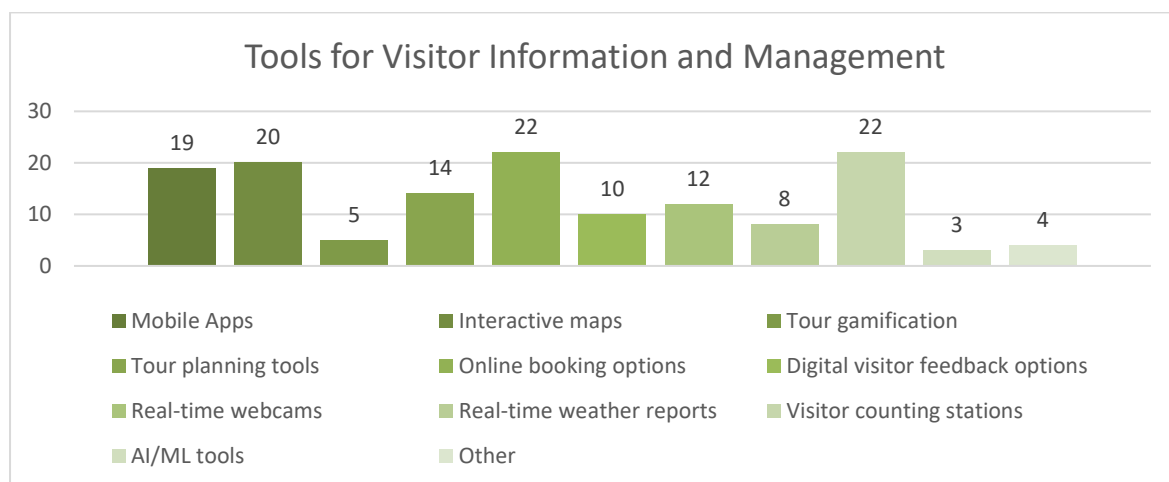| Value	Tool
19	Mobile Apps
20	Interactive maps
5	Tour gamification
14	Tour planning tools
22	Online booking options
10	Digital visitor feedback options
12	Real-time webcams
8	Real-time weather reports
22	Visitor counting stations
3	AI/ML tools
4	Other

Figure 6: Digital tools in usage for visitor information, guidance and management across all participating parks

Regarding the situation of internal and external services, it looks very similar to digital tools used in biodiversity monitoring and management. Figure 7 shows that **20 of 30 parks partly externalize** the **implementation and maintenance of digital technologies for visitor information, guidance and management.** The three parks who indicated providing all of the services themselves are National Park Stelvio, the Wildlife Park Zürich and the National Park Kalkalpen.
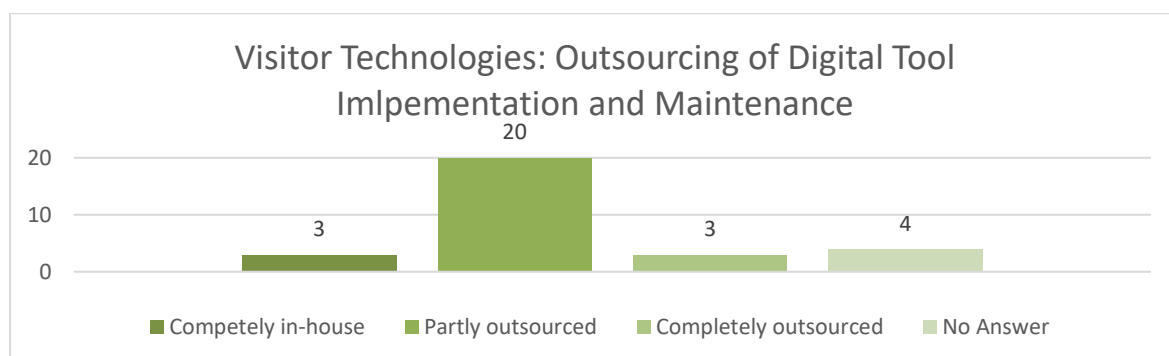

Visitor Technologies: Outsourcing of Digital Tool Imlpementation and Maintenance

Value	Category
3	Competely in-house
20	Partly outsourced
3	Completely outsourced
4	No Answer

Figure 7: Outsourcing of digital tool implementation and maintenance in visitor information and management

With regards to the **challenges** that the parks face for the Implementation of digital tools in visitor information and management, again, most parks (26) name **budget constraints**. Also, **insufficient knowledge** of existing tools is, like for biodiversity management and monitoring, a big problem for almost half of the protected areas (14). More so than for biodiversity tools, **technical limitations** appear to pose problems (16), while data management issues are evaluated as challenging by far fewer parks (8).

Almost a third of the parks (12) further indicate some level of **visitor resistance** to digital tools. The

UNESCO Biosphere Entlebuch even reports that their **visitor counters have been repeatedly demolished** by visitors in the park. Furthermore, one park states that some visitors still prefer paper information, and two others underline how parks should be places of disconnection. This already hints at another barrier: the **resistance of park administration** to digital tools (1) and low interest (1). Also, staff constraints (2) and lack of knowledge in the field appear as problems. One park mentions the need for **specific training** and two others report challenges with efficient **statistical analysis of the data**. Same as with the biodiversity tools, the **lack of mobile reception** in the area poses a significant challenge (4), as well as **time constraints** (5) and the **rapid development of digital tools**.
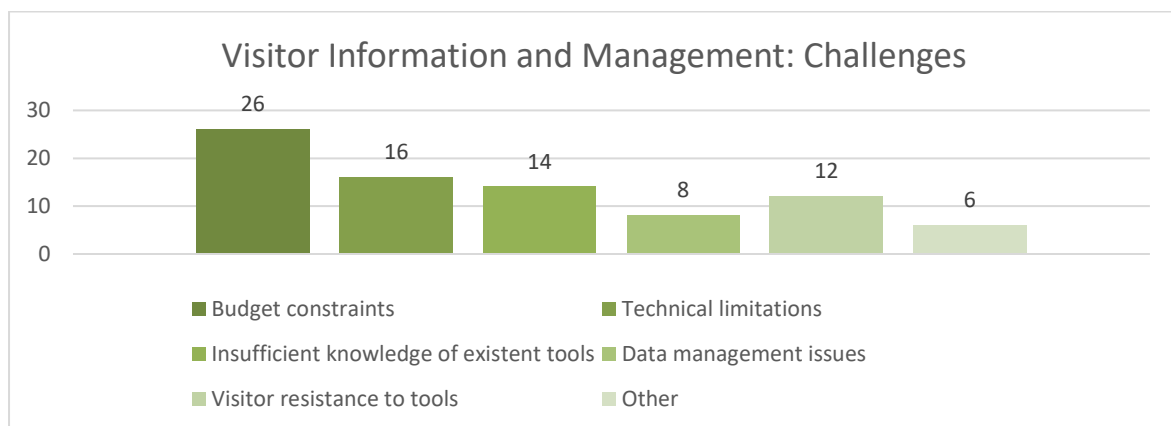

Figure 8: Challenges related to the implementation of digital tools in visitor information and management

As expected, parks evaluate **digital tools** as **more effective for visitor information than for visitor guidance** (Figure 9). The Nature Park Dobratsch and Weissensee, who ranked the effectiveness of digital tools to guide visitors to better conserve nature with 1, mentions that information is misused online to foster curiosity. On a more positive note, the National Park Kalkalpen stresses the importance of cooperating with big online touring platforms to avoid routes threatening conservation aims.
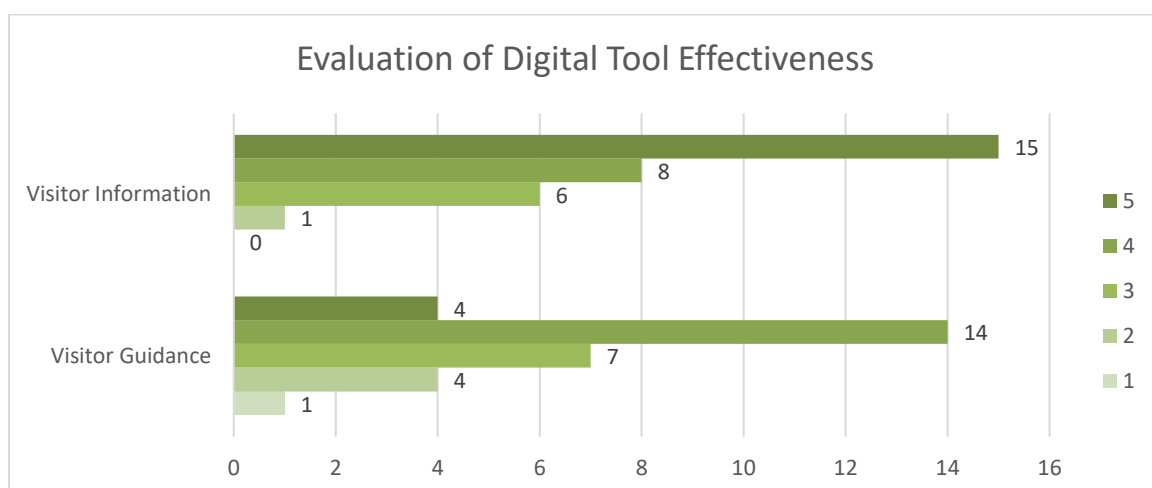

Figure 9: Evaluation of digital tool effectiveness for visitor information and guidance

Since the influence of actors on Social Media and open content outdoor platforms in steering visitors is a very current topic, **ALPARC conducted interviews** with the Nature Park Karwendel, the National Park Gesäuse and the National Park Berchtesgaden. The following 'Zoom-ins' into their best-practice examples aim at helping other Alpine Protected Areas who consider similar interventions.

Nature Park Karwendel: The Office of the Digital Ranger

Interview with Anton Heufelder (Director), Marina Hausberger (Deputy Director) and Iris Trikha (Digital Ranger)

Overview

What are the specific tasks of the digital ranger?	I spend most of my time on social media to see what visitors are doing. Then, I inform them if they are not complying with regulations. I usually send private messages, because I think people react better when they are not publicly paraded. If that does not work at all, I sometimes write public comments.
What specific difficulties does the office of the digital ranger face?	When I write to private individuals, they usually answer me quickly. A bigger challenge remains to reach the influencers. There are cases in which influencers simply do not answer at all.
Do you also supervise the implementation of digital technologies in other areas than visitor guidance?	We have submitted a digitization package to the Land Tyrol, the so-called 'Leuchtturm'-project. This includes the position of the digital ranger, as well as a ranger app, which is intended to make the rangers' work in the field more efficient. Therefore, it goes hand in hand, as our rangers can then use this app in the field for various purposes, such as biodiversity monitoring or visitor guidance.

Collaborative exchange with protected areas

Would you advise other parks to introduce the office of a digital ranger?	Yes! The earlier a protected area starts, the better. The earlier I can inform people, i.e., already during tour planning, which usually happens online, the sooner I have a chance to guide visitors more successfully. If I only start when the visitors are already on site, it becomes a lot more difficult.
Are you already in exchange with other protected areas with regard to your digital ranger?	When our digital ranger started, we spent half a day in the National Park Berchtesgaden to see what the tasks of their ranger were. Of course, they have a lot more resources than we do, but it was still valuable to see what works and what does not. This can be very helpful to make good use of the resources that are available to you. We also have a **digital ranger regulars' table**, mainly with rangers from Germany - An exchange that is very valuable.

International cooperation

How can ALPARC help?	ALPARC can help to create an overview of what initiatives and tools are available. It is most important to stay in touch. Everyone has different experiences, with different approaches and focuses. If we bring this swarm intelligence together, then everyone can benefit.

ALPARC also interviewed Katharina Meyer, the digital ranger of the National Park Berchtesgaden, to learn about her tasks.

I check the tour portals, blogs and apps platforms and take measures to reduce the critical content. Based on this, I compile statistics to identify trends: Are more tours being posted? Are people using more ready-made tours or are they planning the tours themselves? I write to authors of critical tours. I also **change Open Street Map**, which is the database for many tour portals. Komoot, for instance, doesn't really delete tours itself, as they are often smart tours generated by an algorithm, so you can't contact specific people. However, if you change Open Street Map, this will show up in Komoot, allowing you to exert influence. However, these changes can be undone by other people. I also **digitize our rules in Digitize the Planet** which are then displayed on, e.g., Outdooractive, so that every user looking for or planning a tour in our park is shown these rules directly.

Overview	
How did the project come about? What was the idea behind the project?	Komoot initiated the project by approaching National Parks Austria which in turn contacted us. The idea was to send influencers to parks and have them produce content for the benefit of visitor guidance, and to raise awareness for nature conservation. We tried to play out our content via the influencers, hoping that Komoot as a platform would also become more sensitive to the topic.
What happened on the guided tours and what role did the ranger play?	This summer, we sent influencers on a 2-day tour with a ranger from our park. They stayed in a hut overnight. A total of 5 or 6 influencers took part, 2-3 of them with quite a high reach on social media. All of them had to do with mountain sports on their channels. I designed a tour and chose a ranger to accompany them. After a briefing the first morning, the ranger took over. I urged the ranger to include topics of visitor management. First of all, he clarified the question of what a National Park is, and I chose the route in such a way that the different areas of the National Park became well visible. The ranger explained why we steer, which species we protect and where.
What was Komoot's role in the course of the project?	Komoot checked the quality of the tours and organized some things in advance, like organizing the influencers. Also, they covered all costs (overnight stays, rangers). I have always discussed all my content and expectations directly with Komoot.
Output of the project	
What message should the influencers spread?	To be careful in the mountains, to stick to rules and to explain why. Of course, we, or National Parks Austria, briefed them before and during the tours. In some cases, they have seen the posts in advance, in others it has not been coordinated. In that case, we did not have much control over the posts.
What was the measurable output of the tours?	**Within two weeks, the influencers achieved the reach that we have on Facebook in a year.** Especially via Instagram, which we don't use much ourselves yet.
Working with Influencers and Recommendations	
Do you work with influencers in any other way?	We often get inquiries from influencers. But I'm always rather cautious about that, we don't have the budget to pay them and most have only a moderate reach. Also, we have a Facebook channel ourselves with over 80,000 followers. Within the framework of **media scholarships**, through National Parks Austria, **we sometimes host scholarship holders** that then spend two weeks in the National Park and produce content here. Another reason why we are a little reluctant to work with influencers is that, if a person becomes too much our face, then it is dangerous if they move in difficult directions that no longer suit us. You can't control that anymore.
What recommendations would you give other parks?	Take a good look at what kind of content people produce. Also, see how fit they are, because not everyone can walk 1000-1500 meters of altitude. And you have to think carefully about the routes. The route I had chosen was rated very positively, because people often don't really know what a National Park is. If you show them a commercial forest, then go into a jungle-like forest, and finally walk through alpine meadows, they will get a holistic view of what makes a National Park.

National Park Berchtesgaden: A New Visitor Monitoring System

Interview with Katharina Meyer (Digital Ranger)

Overview	
You are developing a visitor monitoring system. How do you envisage this?	It's mainly about gaining insights into visitor behavior, visitor numbers and visitor distribution. This is standard practice in many protected areas, and most of them in Germany probably do it now. Counting systems are set up at important points, which then provide an overview of where there is a lot going on. Of course, this also gives us a better idea of where it is worth putting up signs and positioning rangers. We can calculate the total number of visitors and recognize long-term trends. Are there peak times and days? Also: what do people do, do they go hiking or cycling? The data can then also be used in research, for example to find out more about the reactions of wild animals to human activities.
How far have you progressed in implementing the system?	This year was more of a test phase, we have installed all but one counting station, but there were still a few errors. The steepness of the terrain makes it even more difficult to install them. The project is due to start in full next year.
What measures can be taken based on the findings of the monitoring system?	**We can deploy our staff accordingly**. For example, in zones where cycling is prohibited, we can check when cyclists are more likely to be there and then send rangers to do educational work. The data is also important for **path construction**: you can then consider which paths are particularly popular and therefore have priority when something needs to be repaired. And, of course, the question of whether we need to **intervene in terms of nature conservation** - which, of course, is not so easy due to the right of free access. Otherwise, we just put up information signs, do educational work, etc.

Digital Technologies for Visitor Management	
What digital technologies are used in this visitor monitoring system?	The system works via induction and infrared sensors and can therefore detect the number and direction of cars, bicycles and people (or even cows...). It is not a camera, so it is not possible to draw any conclusions about a person. It's just that the change in infrared radiation is detected by body heat. The induction loop in the ground can measure whether it was a car or a bicycle, similar to a traffic light. We also carry out calibration counts to see whether the counter is working. Of course, there are always minor inaccuracies, but overall you can get a good figure.
Do you also use mobile phone tracking?	Not yet. That would also be difficult for data protection reasons. If you did, you could perhaps buy in data, but that is not planned so far.

International Cooperation	
You have indicated that you are interested in future collaborations with other parks. Do you have specific topics in mind?	We are already networked with various National Parks. What would be exciting is the **joint processing of Open Street Maps**, for example by **drawing up joint guidelines** in order to achieve even more together. But I think that's already starting. I don't have anything particular in mind when it comes to monitoring. We are cooperating with the Technical University of Munich to create a survey supplementing our monitoring system and are also in dialogue with other parks. Generally, I think we are on a good path working together.

Now, the last question in the survey of this thematic block asked participants whether they collaborate with any applications to improve visitor guidance in their park. 23 of the parks answered this question with yes, 7 with no. **Most** of the APAs that specified who they **collaborated with** mentioned 'Outdooractive'. To help review the applications available, we put together a list in Table 2.

Planification and preparation of itineraries for visitors through maps	Visorando Outdooractive Komoot Strava Waze maPZS Camp2Camp Skitour.fr Outdoorvision Cirkwi
Digitalization of regulations, zoning, rules of conduct etc. and integration into outdoor platforms	Digitize the planet
Online booking systems	Regiondo, Alliance Réseaux
Visitor data management	Apidae
Creation of own maps showing attractions of the area	Contwise Geotrek
Creation of 3D cartography of the area in which touristic offers can be integrated	Kalkin
Table 2: List of available online applications for visitor guidance purposes	

Some other interesting tools used for visitor information are, e.g., the use of **virtual reality headsets** in the Nature Park Adamello Brenta to give disabled people the possibility to explore parts of the park where they are not able to go. The Nature Park Karwendel further developed and uses digital WÖFFI, an online brochure and tour collection to facilitate hiking with public transportation facilities.

4 Tools for other Missions of Alpine Protected Areas

Other areas in APAs in which digital tools are used include park and trail monitoring, weather monitoring, park management and educational work with schools. In the survey, **12 parks** indicated using some sort of **digital tools for park management purposes**. These include databases, as in the case of National Park Hohe Tauern Tyrol and Carinthia, project management tools (National Park Ecrins), ranger apps (Nature Park Karwendel), such as mobile web maps and dashboards (Wildlife Park Zürich). **Almost as many (11) parks use digital park and monitoring tools.** In this context, some parks mention visitor counting stations again. The National Park Hohe Tauern Tyrol makes use of an SOS guidepost database and exchanges with the emergency dispatch center.
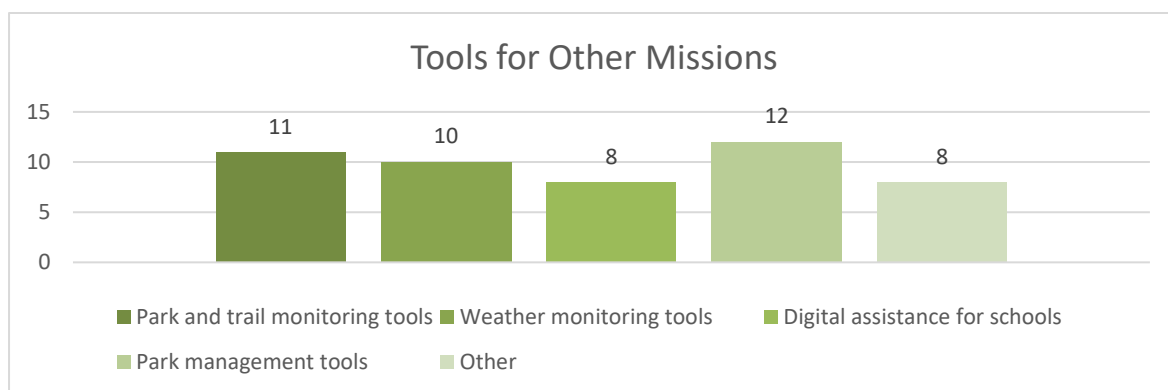
Figure 10: Digital tools in usage for other missions of Alpine Protected Areas across all participants

Also, 10 parks mention digital tools for weather monitoring. Another 8 parks use some sort of **digital assistance in their work with schools**, whereby the National Park Hohe Tauern Tyrol mentions their program 'Klimaschule online' and the National Park Triglav their online classroom where schools can access interactive learning material.

5 Outlook and Future Collaborations

The final section of the survey asked participants about their future plans regarding digital tool implementation. **In both the fields of biodiversity and visitors**, most of the parks are leaning towards new digital technologies in the next 1-2 years but are **still exploring their options** (see Figure 11). Some also have specific tools in mind, however, not for AI/ML technologies where most parks (12) are currently not planning new tools, and some are exploring their options (8). The National Park Ecrins plans to monitor park visitors with camera traps and AI detection in the future.
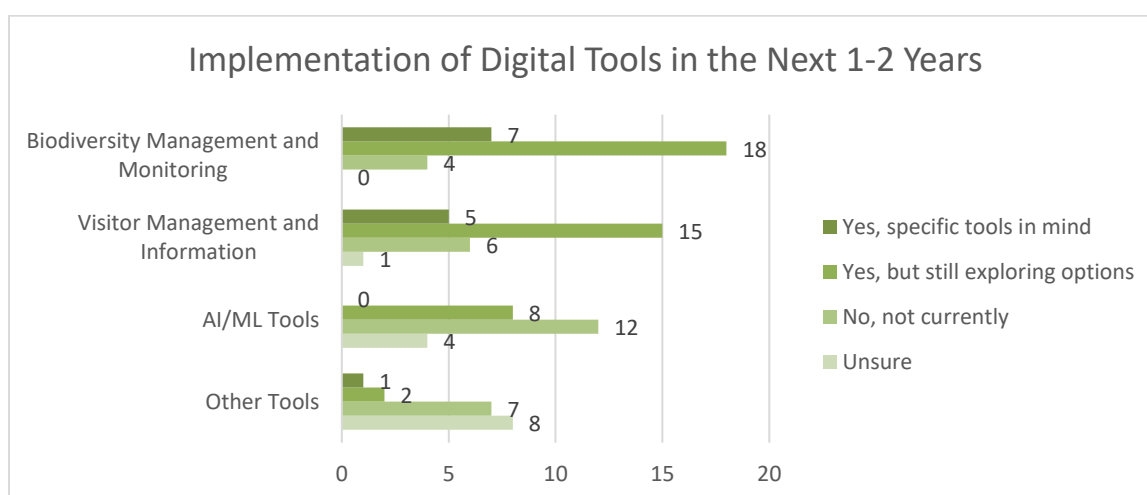
Figure 11: Plans for digital tool implementation in the next 1-2 years by area

Before asking participants about their plans for future collaborations, we asked them whether they are **currently collaborating with any other parks or organizations. 28 of the parks** answered this question

with yes, 1 with no and 1 did not give an answer. Collaborations ranged from bilateral cooperations with other parks, as well as through networks like Swiss Parks or National Parks Austria, regional entities (e.g., Land Tyrol), over universities to private companies (e.g., Bernard Group).

Finally, the parks were able to indicate their level of interest in future collaborations with other protected areas. **Almost all parks (28) were to some extent interested in connecting with other parks to exchange about and collaborate on digital tool implementation** (see Figure 12).
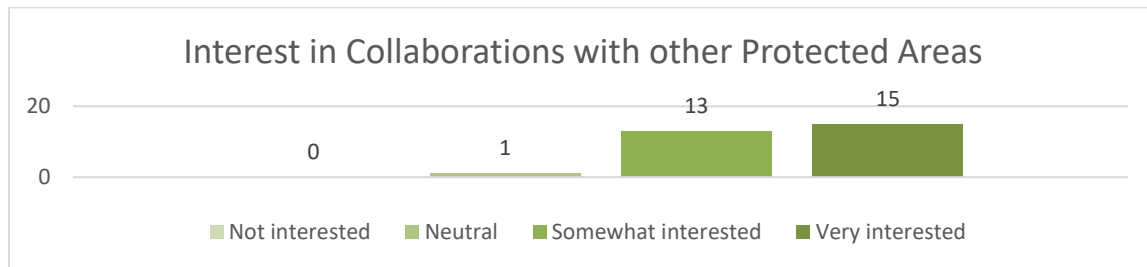
Figure 12: Interest in collaborating with other Alpine Protected Areas in the future

6 Conclusion

The survey underlines the importance of digital technologies for the different missions of APAs.

Here are some takeaways around **biodiversity monitoring and management**:

- **Data management software** is used by most parks (29 of 30), with some of them being part of larger data networks. Half of the parks **encounter issues due to data management**.

- While camera traps, sensors, GPS-tracking and remote sensing tools are very common, **fewer parks use AI/ML technology**. Nonetheless, **a third** of the parks are already using such tools.

- The most common problem among parks regarding new tool implementation is **budget constraints.** Insufficient knowledge of tools, technical, as well as staff and training limitations are also common.

Takeaways around **visitor information, guidance and management**:

- **Most common tools** in this area are **online booking options** and **visitor counting stations**. For the latter, some of the parks use **AI/ML technology** for image recognition – however, much less so than in the field of biodiversity monitoring. This is likely to be due to **data protection concerns**. Instead, some use **mobile phone data tracking.**
- **Many** parks use **mobile Apps**, often in **collaboration** with existing providers. **Tour gamification** is much **less common.**
- Again, **budget constraints** pose the largest challenge. **Insufficient knowledge** is also a problem, as well as **technical limitations** – more so than for biodiversity management. Hereby, **statistical analysis** plays a role. Data management issues occur less often.
- Around one-third of parks report **visitor resistance**, with one park even experiencing vandalism of digital counters. Additionally, some parks face **internal resistance**, as digital technologies clash with the ethos of natural disconnection that certain visitors and staff prefer.
- **Visitor guidance with digital technologies** is a key topic in many parks – many evaluate their effectiveness as moderate to poor. Innovative approaches include the implementation of a **digital ranger**, as done by Nature Park Karwendel and the National Park Berchtesgaden. Also, the National Park Gesäuse did **guided tours with influencers**, in cooperation with Komoot and National Parks Austria.

Regarding future tools, parks set their focus particularly on digital advancement in biodiversity management. They are mostly still exploring their options, also in the field of visitor tools, and AI/ML technology, where less advancement is planned. **Almost all participating parks would be interested in collaborating with other APAs in the future.**

Interested APAs can find a list of applications used by other parks in the field of visitor information, guidance and management (page 14), as well as three in-depth interviews (page 11-13) and digital profiles of all participating National Parks (page 18-25).

This report uncovers the current status of tool implementation, highlights innovative ideas, maps the common challenges of APAs and helps them to collaborate in the future. As put by Anton Heufelder, the director of the Nature Park Karwendel: *"It is most important to stay in touch. Everyone has different experiences, with different approaches and focuses. If we bring this swarm intelligence together, then everyone can benefit."*

7 Overview: National Parks

This section provides an overview of the tools in place in the participating National Parks. The summary tables are based on the survey responses and an additional web search carried out by ALPARC. **They do not claim to be exhaustive.**

Germany

National Park Berchtesgaden

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- Camera traps, sensors (microclimate loggers), GPS trackers, audio recorders - Remote sensing tools (Airborne Laserscanning), AI/ML tools; data management softwares (GIS) - Climate measurement stations for research and safety purposes - Since 2021 permanent biodiversity monitoring on 54 different plots with different measurement tools and devices - PHD student who is developing a program to automatically evaluate images from wildlife cameras - Own App for bark beetle management and Wild life regulation
Technical tools for visitor management and information	- Park App: Map, additional info incorporated in maps like names of mountain peaks, altitudes, restaurants; visitor tips; info on tours, mountain huts, alpine pastures, virtual panorama; tracking tool to record tours, georeferencing to check own position (no longer actively promoted, no new content being created) - YouTube videos to inform about rules of the park - Interactive content: 'Actionbound'-App to explore digitally supported tours - Real-time webcams - Internet access at some information points - Signs with additional information via QR-code installed around the park - Planning tools: Outdooractive, Komoot and Bikemap - Online booking options - Visitor counting stations
Technical tools for other tasks and missions of alpine protected areas	- Visitor counting (Car, bikes, hikers) - Weather monitoring tools - Park management tools

Austria

National Park Gesäuse

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- Information systems: Takes part in parcs.at, a central database where science reports etc. are stored and openly available; GIS-Geodatabase for spatial data; bio mapping catalogue; biodiversity database present in GBIF etc. - Photo traps and audio logger for species monitoring, electrofishing, mapping, GIS-modelling, datalogger, meteorological stations, sensors, DNA/eDNA sampling - Online form for visitors to report species sightings
Technical tools for visitor management and information	- Online event calendar with direct booking options, database shared with tourism agency - The park's own online shop - Real-time webcams and weather information - Visitor feedback: Online rating options of e.g., tours and trails - Visitor counting stations - Separate website presenting the partner network of the national park, online booking of accommodation via this website - Website template for partner companies - Website with interactive "story-maps", showing the historic development of the park's landscape - Visitor analysis and counting via mobile phone tracking
Technical tools for other tasks and missions of alpine protected areas	- Learning material for school classes available for download

National Park Kalkalpen

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- Water measurement stations, emergency traps, sensors - Orthophotos (aerial cameras and drones) - Photo traps for species monitoring (lynx) - Open time-series biotope mapping databases; digitally recorded mapping routes of certain species - Information systems using central digital databases and GIS, openly available online; GIS-tolls for bark-beetle management and territory protection - Longtime monitoring by the Federal Environment Agency, use of sensors and sample examination; eddy-covariance system for CO_2 and water vapor fluxes, soil respiration autio-chambers, optical multi-parameter probe for measuring dissolved nitrogen and carbon - Clearing station for meteorological parameters measurement - Automatic transmission of weather and water level data to the Internet - Online form for visitors to report sightings of species
Technical tools for visitor	- Virtual tour of the parc, providing also additional information

management and information	- A lot of information on biodiversity and cultural knowledge in the parc, available in different formats on the website (e.g., as a diary)
	- Expositions on the ground, using different tools like tablets
	- Interactive online maps with tour material
	- Searching tool for accommodation and restaurants with detailed information on services and equipment
	- Online booking of tours and rangers via redirection to other websites
	- One real-time webcam
	- Weather reports: 3 weather stations in the park are online https://www.kalkalpen.at/messstationen
	- 4 counting stations (using sensors), two of these online
Technical tools for other tasks and missions of alpine protected areas	- Knowledge database gathering information in form of reports, maps, technical and newspaper articles about the parc; openly available on the Website
	- Map providing information on current work sites and closures
	- Online learning material for school classes

National Park Hohe Tauern[3]

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- GPS tracking of certain species, genetic monitoring
	- Temperature sensors, datalogger
	- Remote sensing tools: aerial photos
	- use of AI/ML technologies in data analysis (e.g., image recognition methods, audio analysis of birds)
	- Data management: automated data collection, time Series Data for sustainable documentation, networking through integration into (mega-)data platforms (parcs.at) and research networks; GIS, Metadata-System (parcs network), SDE/Oracle for geodata, Oracle for weather-station, observation.org app, ArcGIS Online tools
	- Online databases openly available (geo data, flora, fauna, glaciers etc.)
	- App for vegetation mapping
	- Possibility for visitors to write email reporting sight of certain species
Technical tools for visitor management and information	- The parc's own WebApp
	- Interactive map with search function
	- Real-time webcams (only Carinthia confirms)
	- Website listing local partners, online booking options
	- Information videos about rules in parc on YouTube
	- Tour bookings available on website and WebApp
	- Audio guided tours on the ground
	- The national park's own podcast
	- Tour planning tools (Carinthia)
	- AI/ML tools: for visitor-counting (camera-system)
	- Digital feedback options

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[3] This table puts together the answers from all three sections of the Hohe Tauern National Park because of their common website through which the background research was conducted. There are some distinctions made due to differing survey answers.

	- Real-time weather reports (Weather box Tyrol for tour planning)
Technical tools for other tasks and missions of alpine protected areas	- Online booking of educational programs for school classes - Park and trail monitoring tools: SOS guidepost database and exchange with emergency dispatch center (Tyrol) - Weather monitoring tools: own weather-station - Digital assistance for environmental education in schools (Klimaschule) - Park management tools: parcs Metadatabase, BioOffice Biodiversity database, GBIF node

France

National Park Ecrins

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- GPS collars to track ibex; ended, with Followdem to manage and publish data (https://github.com/PnEcrins/FollowDem) - Video surveillance, camera traps, acoustic detection of species - DeepFaune (AI image recognition) and GeoCam/Ecosecrets (project of deployment to manage camera traps and their images/videos) - Various climate sensors + istSOS (opensource solution) to manage sensors and their data (https://capteurs.ecrins-parcnational.fr) - Glacier monitoring via photographs, topographic surveys, accumulation and ablation measurements - Information technology: data collected by rangers via digital tablets - Park database to list and locate all studies carried out in the national park - Data management software: QGIS, Geotrek, GeoNature, LibreOffice, R
Technical tools for visitor management and information	- Tours available on website via useful tool, also as version for mobile phones 'Destinations Ecrins'; can be used without Internet, option to download GPS data; app available for the 'Grand Tour des Ecrins' with a map, info on accommodation, paths, own location - Mobile Apps: Geotrek Rando - Interactive Maps: Geotrek-admin & Geotrek-rando + Outdoorvision - Tour planning tools: Geotrek - Online booking options: Geotrek and Alliance Réseaux - Visitor feeback options: Suricate - Weather reports: Meteo France widget - Counting stations: Eco-counters - AI/ML tools: Experimental IA photo detection & analysis (https://github.com/Attendance-PNE-OFB/yolov8-attendance)
Technical tools for other tasks and missions of alpine protected areas	- Geotrek management software application geolocates, maps and displays all trail interventions and work sites - Park management tools: EVA (to manage projects)

National Park Vanoise

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- Database Géonature - Database available on request; data from over 30 years of observation - Online database with scientific studies on the park - Tablet computers for inventory of plant species; direct transmittance to the park's database - Camera traps, GPS tracking devices
Technical tools for visitor management and information	- The park's own podcast - Interactive map with integrated photo gallery (geolocated photos) and different filtering options - Enormous photo gallery with its own website: phototheque.vanoise-parcnational.fr - YouTube Channel with content on animals, plants, such as tours - Interactive map with tour suggestions ans information : rando.vanoise.com - Online shop with direct booking options: boutique.vanoise-parcnational.fr - Mobile Apps - Visitor counting stations (report many problems with them)
Technical tools for other tasks and missions of alpine protected areas	- None

Italy

National Park Stelvio

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- Camera traps, temperature sensors, drones, genetic/bioinformatic tools - Citizen science project to gather data: participants can forward their own observations about e.g., a certain species, while in the national park; observations gathered through an app or a form - Part of the Alpine Biodiversity Project
Technical tools for visitor management and information	- Visitor centers with interactive educational programs and multimedia expositions; online booking of tours, educational programs for students, ski passes, and hotels via the parc's website - Online interactive maps and tour material for planning - Real-time webcams online - Mobile app - Counting stations - Real-time weather reports
Technical tools for other tasks and missions of alpine protected areas	- Enhancement of local business: Sustainability assessment of local producers, ratings available online; additional website dedicated to local producers - Weather monitoring tools

Dolomiti Bellunesi National Park

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- Camera traps for wildlife monitoring - Sensors: data logger for temperature measurements - GPS collars for wolf ethology study - Data management software
Technical tools for visitor management and information	- Very detailed online information about the flora, fauna and the history of the park - Interactive map with locations of accommodation, restaurants, train stations, villages, local manufacturers; information on trails - Tour proposals with map information - Online search tool for accommodation, restaurants, local manufacturers - Online newsletter - Visitor feedback tool: online diary, possibility to send own experiences which are then shared on the website - Photo, video and audio gallery of the park - Virtual flights over the park - External weather information via wwwold.arpa.veneto.it - Online shopping option of tourist guide via emporio.parks.it
Technical tools for other tasks and missions of alpine protected areas	- Information on park excursions for school classes on website; booking via email

Slovenia

National Park Triglav

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- Camera traps used for monitoring at different locations in park - GPS tracking of endangered species - Remote sensing tools - Data management software - Tablets for plant monitoring
Technical tools for visitor management and information	- Counting: sensors that count hikers, bicycles and cars (with interactive online map where visitors can see locations of these stations) - Strava mobile app - Interactive maps - Tour planning tools - Online booking options - Real-time webcams for visitor management - Real-time weather report
Technical tools for other tasks and missions of alpine protected areas	- Weather stations - Digital assistance for environmental education in schools - Park management tools

Switzerland

<u>Swiss National Park</u>

Category	Digital solutions
Technical tools for biodiversity management and monitoring	- Climate stations - (GIS) applications; Statistical & remote sensing softwares - Drones, aerial and satellite imagery - Openly accessible database storing GIS-data, projects, publications, long time monitoring information etc. http://www.parcs.ch/snp/data.php - Camera traps: systematic, opportunistic, small mammal traps - Sensors: climate soil temperature, sound logger, water physics and chemistry - GPS trackers: different animals, ungulates, foxes - AI/ML tools (not indicated which) - Data capturing tools (Field Maps)
Technical tools for visitor management and information	- Map that shows current science programs on the ground - The park's own app: podcasts; 360° panorama; visitor information regarding the park's management, flora, fauna, accommodation, restaurants; most content available offline; tour guide with interactive map and own location; available in three languages - Flower Walks App - Audio-guided, interactive tours on the ground (supported by the app); tour gamification like scavenger hunts - Digitally supported exhibitions on the ground - Search tool for events - Online booking tool for tours and events - Real-time webcams - Real-time weather reports - Visitor counting; app for visitor monitoring - Related AI/ML tools
Technical tools for other tasks and missions of alpine protected areas	- Interactive map-application for park rangers to control signages - Interactive map-applications for project planning (landscape changes) - Online educational material