



Outdoor Sports Infrastructure Planning – Hiking and Mountain Biking

Hiking and mountain biking are extremely popular sports activities. Especially in mountain areas, they are the two main summertime leisure activities. Many natural habitats, however, have been affected by the frequent presence of large numbers of people; conflicts between different kinds of users have also arisen. It is therefore essential to observe best practices in the planning and design of infrastructure for outdoor leisure activities. This Fact Sheet has been written with hikers and mountain bikers in mind. It presents various planning tools for conflict prevention or resolution, and provides an overview of likely future challenges.

Why do we need infrastructure planning for hiking and mountain biking?

Nature-oriented outdoor sports in Switzerland

In Switzerland, leisure sports activities have seen a steady increase over the past forty years. While around seventy or eighty percent of the country's total population of around eight million have always been actively engaged in sports, more recently there has been a marked increase – from twenty to fifty percent – in the number of people playing sports several times a week (see Lamprecht et al 2014), and in the popularity of outdoor sports, led by cycling, hiking, swimming and skiing. In 2014, there were some 2.7 million hikers, 2.4 million cyclists and 400,000 mountain bikers in Switzerland – and rising across the board (see Lamprecht et al 2014; Rikus et al 2015). This has also increased the pressure on infrastructure and on the natural environment.

Unsurprisingly, hiking and mountain biking are extremely popular in rural tourist destinations, in the mountains, and even in parks and protected areas. Nature-oriented tourists

chiefly engage in these two sports (see Siegrist et al 2015) and destinations have been promoting these summer activities not least to make up for decreasing winter revenues. Larger numbers of mountain biking trails are being signposted and more designated ones constructed.

A brief history of the two sports

While *Homo sapiens* has always been a 'walking animal', walking only became a leisure activity in the early 18th century. The fact that it has become a favourite outdoor sport in Switzerland and elsewhere is also reflected in the evolution of hiking equipment. For decades, hikers wore and used general-purpose clothing and other equipment. That has changed dramatically, with the sportswear industry educating, as it were, its Nordic Walking customers in particular about the importance of appropriate, high-quality outfits, both in terms of hiker safety and to enhance outdoor well-being. These days, therefore, most hikers use high-tech clothing, footwear

and equipment. In many countries, hiking has also seen a boost due to signposted trails, precise maps and an increasing awareness of the health benefits of outdoor activities. More recently, people preparing for a hike have also come to rely on digital maps and online trip planners alongside traditional maps.

By contrast to hiking, mountain biking is a more recent phenomenon. The sport of riding specially designed bicycles off-road, often over rugged terrain, first made headlines in California in the mid-1970s and has since become a mainstream sport. Technological innovations and different riding styles led to a range of categories, which are not always easy to distinguish. They include Cross-Country (XC), All-mountain/Enduro (AM), Mountain Bike Touring or Marathon, Downhill (DH), Four-cross/Dual Slalom, Freeride, Dirt Jumping (DJ), Race and Trials. New trails and areas have become accessible to mountain biking owing to more recent technological advances, including electric motor conversions. According to various authors, the first three (or five) categories listed above represent between 70 and 90 percent of all mountain biking activity in Austria, Germany and Switzerland. The focus of this Fact Sheet therefore lies on these categories.

How and why do conflicts arise between different user categories?

Traditional Swiss hiking trails were used exclusively by people on foot until the 1980s. Since then, however, mountain bikers have also begun to use these trails, occasionally to the point where they constitute the majority of users. This has given rise to conflicts between different users. In one analysis (see Mann 2006), such conflicts are due to divergent interpretations and assessments of specific recreational situations. Direct conflicts arise from immediate encounters. By contrast, indirect conflicts are the result of the perceived presence of other categories of users. Conflicts tend to be asymmetrical, with hikers perceiving mountain bikers as more of a nuisance than vice-versa. Within the same type of sport, user conflicts may arise from a sense of overcrowding, from a lack of tolerance of the presence of other people, or from their behaviour, such as littering.

Hikers, joggers (and horseback riders) have described the following causes of conflicts with mountain bikers:

- new group uses same area and infrastructure
- outfits, especially protective equipment (integral helmets)
- speed difference
- startlingly sudden appearance of mountain bikers
- collisions, near collisions
- conflict of interests (nature observation, hunting)
- fear that 'a mountain biker might appear'
- group with a different life-style and different values
- nuisance or anti-social behaviour ('mountain bikers don't slow down or give way')

What is the negative impact of hiking and mountain biking on the natural environment?

Against prevalent perceptions, studies such as Marion & Wimpey (2007) and Pickering et al (2010) have found little difference between hiking and mountain biking in terms of their environmental and infrastructure impact.

However, local situations are closely related to whether and to what degree environmental impacts are manifested (see Table 1). In terms of trail degradation, for example, topography, trail alignment, geology and micro-climate have been found to play a greater role than use type or user frequency.

While there have been similarities in terms of impact (see Table 1), more specific forms have also been found. According to some authors, mountain bikers and their greater speed cause wildlife disturbance, hence have greater impact. The presence of dogs on or off the leash on trails with high user frequency may affect the breeding success of ground-nesting birds (see Ingold 2005). As hikers tend to leave trails more frequently than bikers, they may cause more tread erosion and disturbance to wildlife (Marion & Wimpey 2007; see Scherl 2015; Staeubli 2016).

Table 1: Meta-analysis of environmental impact due to hiking and mountain biking (Rupf 2015)

Impacts	Soil	Vegetation	Wildlife	Landscape	Infrastructure
Direct	Soil compaction	Vegetation loss	Avoidance behaviour	Light emission	Erosion due to trail degradation
	Soil exposure	Height reduction	Habitat restriction		Emergence of new trails ('paths of desire')
	Soil erosion	Biodiversity reduction	Biodiversity reduction		Muddiness
	Disturbance to soil fauna	Damage to plants	Weakened animals		
Indirect		Excessive browsing in retreat areas	Habitat fragmentation	Increase in trail area	
			Reduced breeding success in ground-nesting birds	Emergence of new, often illegal infrastructure	
				Littering	

Weaknesses in Swiss planning procedures for hiking and mountain biking trails

Switzerland is a unique hiking and mountain biking destination: it boasts c.65,000 km (c.40,000 miles) of signposted and marked hiking trails. A joint position paper published in January 2015 by Switzerland's major hiking and biking organisations calls for mutual and respectful use of the trails (see Schweizer Wanderwege et al, eds).

Article 43 of the 1958 Swiss Federal Road Traffic Act (SVG – Schweizerisches Strassenverkehrsgesetz) bans cyclists from using footpaths and hiking trails that are 'unsuitable' for bicycles. Cantonal authorities may, however, enact additional legal provisions; they also enjoy some leeway in how they interpret article 43. This has led to substantial legal differences between various authorities. In canton Appenzell Innerhoden, for example, mountain bikers are only permitted to use designated trails. In canton Grisons, however, unless such use is expressly prohibited, mountain bikers may use all hiking trails. Whether or not a trail is 'suitable' for mountain bikes is therefore a frequent subject of debate.

Moreover, sections of trails do not exist in isolation; they are always part of larger regional trail networks located in more or less sensitive environments; hikers and bikers are also part of these attractive outdoor-sport systems. Entire trail networks are affected by new trail sections, or the closure of old ones; the impact is felt by various (human) user groups and throughout the natural environment. One such fairly recent example is the Belalp–Riederalp hiking trail. Since July 2008, the Aletschji–Grünsee suspension bridge across the Massa Gorge at the foot of the largest Swiss glacier affords

easier access to the Aletsch Forest, a protected area (see Kernen et al 2010).

Most commonly, changes to trail networks are initiated by tourist boards, park management or municipal authorities. In Switzerland, planning permission for new hiking and designated mountain biking trails must be sought from cantonal or municipal authorities. When planning new trails, it is essential to involve at the earliest possible stage both official authorities and organisations that specialise in human-powered mobility (see Bundesamt für Strassen – ASTRA 2016).

Swiss planning procedures currently exhibit a number of weaknesses:

- frequent lack of baseline data regarding specific local and regional user frequencies (hikers and mountain bikers), both for current situation and to monitor post-implementation success
- inadequate knowledge of hiker and mountain biker needs (lack of demand-side data); most often indirectly integrated into planning procedures only by way of expert opinion
- lack of adequate planning instruments has led to missing pre-implementation evaluation of policies and measures affecting hikers and mountain bikers
- frequent lack of accurate information on the environmental impact, of mountain biking in particular.

How can infrastructure planning be improved?

Know your users

'We listen to our visitors.' This is what the tourist industry claims to be doing. But who are the visitors and what are their needs and preferences? Are they happy with what is on offer?

When it comes to hiking and mountain biking, these questions are quite difficult to answer. Some points of conflict have come to light from visitor feedback and, regrettably, accident reports. Elsewhere, the lack of background information is quite obvious. If conflict situations are to be defused and provision optimised, however, it is essential to know how users behave, and why.

Use of existing routes, trails and other infrastructure is indicative of behaviour patterns. Various situational methods, many of which can be combined with each other, are available to record spatial use (see overview in Table 2).

Choice experiment – an integrated user-need survey method

Surveys can be helpful to find out why certain behaviours occur. In terms of outdoor sports, deciding what to do can be

a complex task because a wide range of attributes or factors are closely correlated – take distance and height difference in a day hike, for example.

Choice experiments were used to develop a survey method that allows for the simultaneous retrieval of several contextualised attributes. Respondents were presented with a choice of two realistic day hikes (see Illustration 1). Focus groups including hikers and mountain bikers were important partners, and helped to ensure that choices included all relevant attributes and were presented in an appropriate setting. Attribute dimensions (such as walking distance, etc) were based on actual day hikes or rides, on guide-books and online information and on actual, GPS-recorded routes (772 hiking and 325 biking trails in Val Müstair; see Table 2).

The outcome was a choice-experiment survey of hikers and mountain bikers regarding two different short or longer routes and trails; the short/long distinction was based on GPS analyses at four hours. Between November 2011 and February 2012, 948 hikers and 317 mountain bikers responded to an online survey sent out by e-mail and published on the websites of Swiss outdoor sports associations and specialised shops (see Rupf 2015; samples exhibit negligible demo-

graphic deviations from a representative survey done by Lamprecht et al 2008).

Hikers, mountain bikers and their preferences

The survey showed that seventy-three percent of hikers and sixty percent of mountain bikers tend to plan day hikes or rides lasting over four hours. Moreover, the analysis of the choice experiment resulted in two groups in each category of hikers and mountain bikers, each of which favoured either a short or a long hike or ride with specific preferences (see Rupf 2015).

The most important route and trail selection criteria are summarised in Table 3. The survey found a high correlation of preferred attributes with GPS-recorded routes and/or existing guide-book values. The survey was also able to ascertain how respondents evaluated specific characteristics of each attribute. Here, greater differences emerged between groups. Although the presence of official signposts and waymarkers,

the availability of local produce at shelters, or hides from which to observe wildlife were not among the most important selection criteria, they did have a positive impact. Respondents were also highly respectful of track and trail closures, especially if related to wildlife and natural habitat protection.

New planning tool to assist in the decision-making process

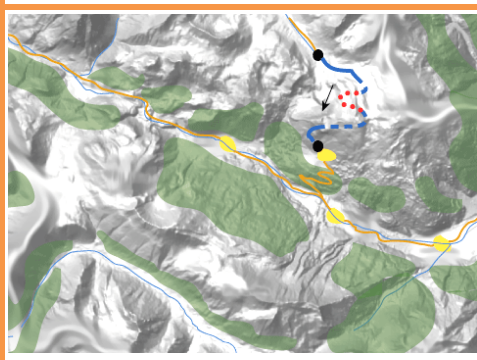
Choice experiment analyses and statistical models led to the development of a new planning tool (multinomial logit model) to assist in the planning and decision-making process for regional hiking and mountain biking trails. The new, user-friendly Excel® tool is available from the author.

The tool can assist in the assessment of both the attractiveness of and possible gaps in existing routes and trails (see Rupf 2015). For example, it allows to establish the percentage of hiker and mountain biking groups who would prefer a new trail layout (Illustration 2: the model shows that between seventy and eighty percent of respondents would prefer the new trail).

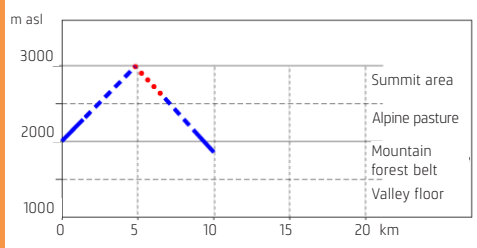
Route selection: Please select 'Route A', 'Route B', or 'Neither'

Imagine you are selecting the route for a day hike from your own home or holiday destination.

Tour A

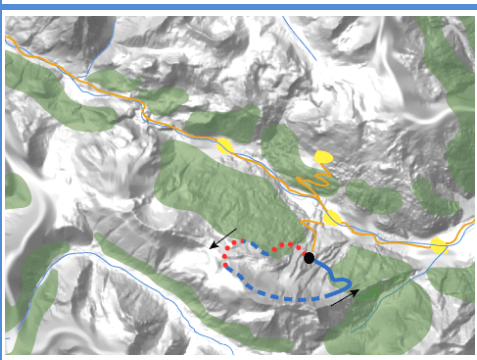


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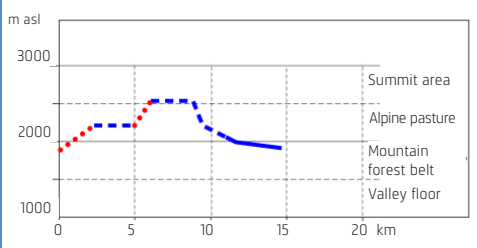


Approximate duration of hike	4 - 5 hours
Views	Views of several valleys
Encounters with other groups (per hour)	More than 10 groups of hikers No bikers
Wildlife observed	rarely

Tour B



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Approximate duration of hike	5 - 6 hours
Views	Good views in every direction
Encounters with other groups (per hour)	1 - 4 groups of hikers 5 - 10 groups of mountain bikers
Wildlife observed	occasionally

Your selection: ☐ Tour A ☐ Tour B ☐ Neither

Illustration 1: Choice experiment of route for a day hike (author's representation). Selection criteria: views; uphill height difference; distance (time required not a criterion in and of itself); altitudinal layer(s); relative height difference; proximity to settlements; mountain (cable) railway; type of trail; position of rugged path (in ascent/descent); circular walk; number of encounters with other hikers and/or mountain bikers; number of potential wildlife observations.

Table 2: Overview of spatial recording methods of outdoor sports activities (see Rupf 2015)

Method	Area of application	Benefits	Disadvantages
Motion-activated infrared camera	Location-specific counts (hikers, mountain bikers, ski tourers, wildlife, etc)	Direction-specific, detailed record of activities; additional information on human or wildlife features	Visible camera; theft risk; data-protection issues (image-blurring possible); high data-evaluation costs
Automated counting system (induction loops, pressure mats, etc)	Location-specific counts (hikers, mountain bikers)	Direction-specific record of passes; combination with pyro sensor enables automated hiker/mountain biker distinction; invisible device; long battery life; automated data transmission independent of electrical supply; largely impervious to weather	Calibration required (at least 1x/yr); risk of imprecision; does not work in snow; high initial cost
Passive infrared sensor (pyro sensor)	Location-specific counts (hikers, mountain bikers, ski tourers)	Quite easy to integrate into setting; independent of ground cover; quite user friendly; long battery life; automated data transmission independent of electrical supply; combination with induction loop enables hiker/mountain biker distinction	Risk of miscounts in wooded areas and on wide trails; quite susceptible to weather, esp. snow, heavy rain, sunshine; high initial cost
GPS tracking – real time	Space-time behaviour; motion tracking at sports events, of (road) traffic, etc	Real-time record (event response); high precision; can record off-trail activity	Short observation period due to high energy consumption (up to c.12hrs); small sample size; quite costly
GPS logging – time-lag	Space-time behaviour; outdoor sports and traffic; validation of other low-tech recording methods	Long observation period (up to c.50hrs); small unattractive device; high precision; can record off-trail activity	Small sample size; quite costly
Smartphone tracking (GPS app)	Space-time behaviour; motion tracking of smartphone user; basic unit for location-based services	High precision; communication with visitors possible; real-time records	Quite costly; short observation period due to short battery-life
Mobile phone tracking	Space-time behaviour; rough motion tracking of mobile-phone user, especially in densely populated areas	Large sample size; long observation period; cost-effective per data set	Imprecise, particularly where network coverage is low; data protection issues as few countries release data
Non-participatory observation	Space-time behaviour; visual tracking of visitors and (some) wildlife in restricted area	Comprehensive recording of behaviour possible	Costly in terms of staff and time; challenging use in larger area or complex terrain
Interview (inc. sketch of route)	Various elements of visitor-provided information including route	Communication with visitors possible; recording of additional visitor-provided information, inc future plans, etc	Costly in terms of staff and time; quite small sample size; imprecise route log
Self-registration (inc. sketch of route)	Recording of visitors and routes	Inexpensive	Quite imprecise as visitors may be unfamiliar with route; unknown sample size

Table 3: Routes and trails preferred by largest hiker and mountain biker groups (n=948 hikers; 317 mountain bikers. In bold: most important route and trail selection criteria.)

Criterion		Hikers – long day hike (75%)	Hikers – short day hike (87%)	Mountain bikers – long day ride (73%)	Mountain bikers – short day ride (82%)
Route Preferences	Distance	14km/8.7mi	8km/5mi	55km/34mi	40km/24.8mi
	Height difference, ascent	1,300m/4,265ft	300m/984ft	1,900m/6,233ft	1,100m/3,609ft
	Relative height difference	-100m to -400m -328ft to -1,312ft	-100m to -400m -328ft to -1,312ft	-600m to -1000m -1,968 to -3,281ft	+200m to -200m +656ft to -656ft
	Altitudinal layer	50% alp, 50% alpine	67% alp, 33% alpine	25% forest, 50% alp, 25% alpine	33% forest, 67% alp
	View/scenery	Good views in every direction	Good views in every direction	Views of several valleys	Good views in every direction
	Trail characteristics	25% vehicle track, 50% good hiking trail, 25% rugged hiking trail	50% good hiking trail, 50% rugged hiking trail	Mostly singletrack trails	Mostly singletrack trails
	Encounters with hikers	None	None	None	None
	Encounters with mountain bikers	None	None	1 to 4 groups/hr	1 to 4 groups/hr
Trail Preferences	Trail characteristics	Rugged, narrow hiking trail	Rugged, narrow hiking trail	Smooth, narrow hiking trail	Rugged, narrow hiking trail
	Gradient	Moderate (c.7%)	level	Moderate (c.7%)	Moderate (c.7%)
	Forested area	25%	25%	n.s.	n.s.
	Encounters with hikers	1 group of hikers/h	1 group of hikers/h	1 group of hikers/h	None
	Encounters with mountain bikers	None	None	n.s.	n.s.
	Rest facilities	Alp shelter providing local produce	Alp shelter providing local produce	Alp shelter providing local produce	Alp shelter providing local produce
	Signposting	Official signposts and waymarkers	Official signposts and waymarkers	Official signposts and waymarkers	Official signposts and waymarkers

(n.s. = of no significance to the model)

Overview of likely future developments and challenges

As the population of Switzerland is on the increase, more and more people are likely to turn to outdoor sports such as hiking and mountain biking. These sports can provide a balance to workplace stress and meet the need for healthy physical activity; they can also be played during the increasingly significant summer season (see Frick et al 2010).

Not only it is likely that there will be more people, we will see a rise in individualisation as well (see Frick et al 2010), resulting in planning and design challenges, and making it more difficult to reach all users.

Technological innovations will continue to drive changes in sports. We are already seeing an increase in gravity-assisted mountain biking, mostly on dedicated flow or downhill trails.

The electric or e-mountain bike has become increasingly popular, especially among older cyclists. It is difficult to estimate its impact in terms of longer rides across larger areas, or less dependency on mountain (cable) railways, etc.

Alongside technological change affecting the sports as such, our lives will also continue to change due to ongoing digitisation. The importance of online routes and communities will continue to grow. Given these unstoppable trends, it makes good sense to provide guidance to hikers and mountain bikers by making proactive use of these technologies.

Finally, but by no means least, researchers will need to stay abreast of developments in relevant sports, enhancing and expanding their knowledge especially in terms of the needs

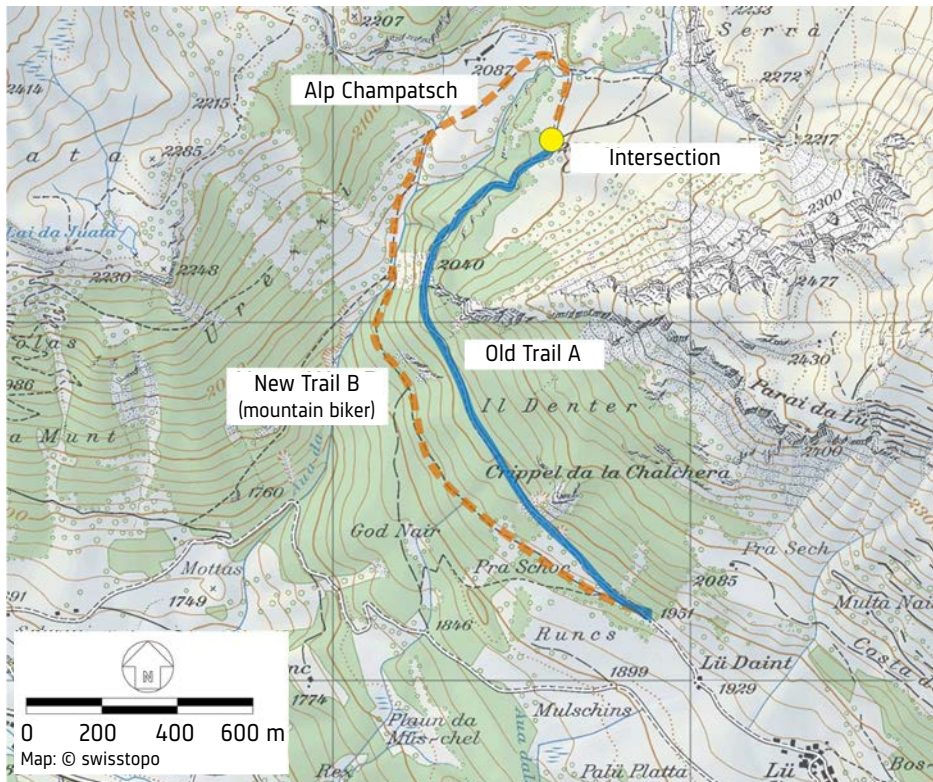


Illustration 2: Planning a new mountainbike trail (author's representation).

and behaviour of hikers and mountain bikers to provide adequate and appropriate information to planners and tourist destinations alike. The emphasis will be on real-data analysis, such as big data in conjunction with local census data. More-

over, the inclusion of wildlife research will enable the design of more precise models including agent-based models that can simulate human and wildlife behaviour simultaneously.

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Recommendations

Planners and tourist destinations alike aim to develop hiking and mountain biking trails, offers and infrastructure that minimise both environmental impact and potential conflicts between different user types. Successful planning and design of outdoor sport networks and infrastructure will consider the following recommendations:

- Any regions should consider hiking and mountain biking as opportunities; any planning procedures should proactively integrate the provision of suitable and sustainable infrastructure.
- In a first step, any potential for conflicts arising from the use of existing facilities, infrastructure and trail networks should be analysed by means of visitor surveys and census methods (see above). The analysis of web-based information such as social media and web-logs where users share details of their hikes and rides is a further useful method.
- Moreover, analyses should include visitor feedback, with a focus on conflict situations, as well as inventories of protected areas and natural habitats.
- Trail networks and routes should not only comply with environmental standards, they should also meet user needs, and should be promoted proactively. Hikers and mountain bikers are more easily guided by attractive routes and trails, whose active promotion also helps to protect wildlife and fragile natural habitats. Where there is a lack of attractive provision, routes and trails published on social media tend to draw large crowds that cause high impact.
- To evaluate the attractiveness of existing and planned routes alike, a new, user-friendly Excel® tool based on statistical models is now available from the author.
- Hikers and mountain bikers share similar if not identical preferences for trail characteristics that should be taken into consideration in planning procedures. These preferences include a natural surface on moderately steep and fairly narrow hiking trails that pass through some forested areas and feature shelters offering local produce. Official signposts and waymarkings are appreciated; most users prefer less frequented trails (see Fischer et al 2015; Rupf 2015).
- The construction of any new trails must comply with official procedures (such as guidelines published by *Bundesamt für Strassen – ASTRA* 2016).
- The availability of new routes, trails and infrastructure should be promoted using relevant and appropriate media, perhaps including user frequencies; online publications will reach mountain bikers in particular.

Taking these recommendations seriously will enable and encourage hikers and mountain bikers to share trail networks. It will also allow the leisure and tourist industries to offer fantastic and satisfying outdoor experiences in a natural environment.

AUTHOR'S NOTES

For more details, please consult Rupf (2015), *Planungsinstrumente für Wandern und Mountainbiking in Berggebieten – unter besonderer Berücksichtigung der Biosfera Val Müstair*.

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