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Research Article

Biking-hiking conflicts and their mitigation in urban recreation areas: Results of a quasi-experimental long-term evaluation in the Zurich forest

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ABSTRACT

Increased recreational use of green spaces in and around cities leads to conflicts between user groups such as bikers and hikers. This study evaluates a broad set of measures to reduce such conflicts in the Uetliberg urban forest in Zurich. Data about conflict perceptions of hikers, bikers and people involved in both activities from three surveys were compared: immediately before (2005), 1.5 years (2006) and 12 years (2017) after the implementation of the visitor management measures.

The results show that not only on short term after the implementation (2006) but also in longer term (2017) there was a broad consensus on the acceptance of the visitor management measures and a high level of satisfaction with the recreation area and other users' behaviour.

Soft measures like the opening of forest paths for bikers and an official bike trail were better accepted than the hard measure of a transport ban for bicycles. Conflict-relevant factors such as a compliant behaviour and the tolerance of others as well as the danger posed by bikers were perceived differently by the user groups. The conflict between bikers and hikers was asymmetrical and experienced more strongly by hikers. Respondents reported mainly out-group conflicts, while in-group conflicts were rarely perceived. The number of reported disturbances by bikers decreased thanks to the measures implemented, in particular due to the separate bike trail as additional infrastructure for bikers.

Management implications: Hikers and bikers move at different speeds. Especially on routes that allow fast biking (e.g., downhill trails), this can cause anxiety among hikers. At least in heavily used recreational areas, such routes should be separated for the two user groups. A combination of different spatial, communicative, and legal measures can reduce conflicts; prohibitions are the least popular.

As far as evaluation is concerned, it seems worthwhile to measure the actual effects of mitigation measures on attitudes and behaviour of the target groups and not only the acceptance of the measures.

1. Introduction

In recent years, outdoor activities have increased in diversity and frequency (Lamprecht et al., 2020). A high pressure of recreational use arose on forests and manifold conflicts between user groups were documented (Hunziker et al., 2012; Tschannen et al., 2006). Public and private land managers, local policy makers and users are concerned about the negative consequences of the high pressure of use. They are faced with the challenging task of maintaining and designing open spaces for outdoor activities for an increasing number of users and preventing conflicts at the same time. The best way for society to meet this challenge is to gain scientific knowledge about outdoor activities and to take, evaluate and optimise management measures.

Mountain biking is a popular, and growing, sport in Switzerland, performed by 7.9% of the population. Most have used a mountain bike trail or a downhill trail at least once in the last year. The average age of Swiss mountain bikers is 45 years, men are more likely than women to practice the sport (76:24) (Lamprecht et al., 2020). Because of their popularity conflicts between hikers and bikers are frequent and are also the subject of various scientific studies (Alleyne, 2008; Carothers et al., 2001; Horn, 1994; Jellum, 2007; Mann & Absher, 2008). Due to fears of social and ecological impacts (Chavez et al., 1993; Morey et al., 2002), biking in the forest is controversial (despite its growing community) and, unlike hiking, is only allowed on a limited basis in most European

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forests (Elands & Wirth, 2010; Zajc & Berzelak, 2016). If mountain biking is not restricted generally, as in Switzerland, the large participation in this activity (Fischer et al., 2021; Goeft & Alder, 2000; Pickering & Rossi, 2016; Webber, 2007) requires the provision of appropriate recreational infrastructure and strategies for compatibility with other uses (Elands & Wirth, 2010; Koemle & Morawetz, 2016; Wilkes-Allemann et al., 2015). Such a strategy was applied in a Swiss forest near Zurich (Uetliberg-mountain) in 2005 where the conflicts between bikers and hikers before became more and more serious. Due to its topography, the study area is attractive for a special kind of cyclists, the so-called mountain-bikers (or just "bikers") who love steep ascents and descents on usually unpaved gravel roads or natural small trails, the so-called single trails, or even specific bike trails, e.g., the so-called downhill trails. These "bikers" use special bicycles the so-called mountain-bikes with large rough tyres and often full-suspension frames. The location of the study area on the outskirts of the city allows city dwellers to enjoy mountain biking in everyday life.

This study compares hikers and bikers' perceptions on conflicts immediately before (2005) and after the implementation of visitor management measures (2006) as well as more recent data of 2017. Thereby, the temporal development of the acceptance of the management measures since 2006 is also assessed. Responding frequent calls for visitor management interventions to be evaluated over the long term (e.g. Anderson et al., 1998; Askew et al., 2017; Bell et al., 2007; Elands & Wirth, 2010; Hadwen et al., 2008; Krämer et al., 2004; Leung & Marion, 2000), the study's findings allow an evaluation of the long-term effect of mountain biking management in a heavily used urban forest.

1.1. State of knowledge and theories

1.1.1. Social conflicts

Social conflicts are observed between different groups, but also within groups and between individuals (Graefe & Thapa, 2004). They arise when values, norms or individual actions are incompatible (Bornstein, 1992; Graefe & Thapa, 2004; Hillmann, 2007; Kunz, 2005). These conflicts can be perceived unilaterally by one or bilaterally by both conflict parties, one speaks of asymmetric or symmetric conflicts (Jacob & Schreyer, 1980).

It is helpful to distinguish two types of conflict that differ in their causes: value and direct conflicts. The former also takes place, when neither the conflict party nor traces of it are encountered on site, and the mere knowledge or belief of the presence of a user group is considered disruptive. It arises when an activity is perceived as inappropriate in itself and opposing value attitudes (e.g., ecocentric and anthropocentric world views, prejudices, different attitudes towards changes in the place of activity and impacts on nature) clash (Cessford, 2003; Wilkes-Allemann et al., 2015). A direct conflict, on the other hand, occurs when the physical presence or action of another person interferes with one's own experience of activity, implied actions, and goals (Carothers et al., 2001; Vaske et al., 2007).

Different risk assessment of hikers and bikers can lead to conflicts. The higher speed of bikers and surprising appearance particularly frighten people who are not used to bikers (Brown, 2016; Cessford, 2003). The more important speed is to bikers, the more likely they experience conflict with hikers (Zajc & Berzelak, 2016). Sharing trail infrastructure requires frequent overtaking and swerving, which can lead to the dislike of multi-use trails (Reichhart & Arnberger, 2010).

1.1.2. Evaluation of management measures

A large number of studies (Immoos & Hunziker, 2014; Krämer et al., 2004; Marion & Reid, 2007; Park et al., 2008) indicate that targeted management can reduce social interference between activities and increase satisfaction of all visitors. Several personal-, cultural- and activity-related factors influence the preference for management measures. In general, hard measures such as fines and bans are less accepted than soft measures such as service and infrastructure tools, imparting of knowledge and behavioural options (Elands & Wirth, 2010; Mosler & Tobias, 2007; Zeidenitz, 2005). At best, both are developed with the target groups and communicated reliably via experts and role models, as could be achieved in the example of the conflict between snow sports and nature conservation (Hubschmid & Hunziker, 2018). Arnberger et al. (2018) monitored mountain-biking use in one biking hot spot of the Vienna Wood Biosphere Reserve in Austria and tested the success of the reorganization of mountain bike trails and areas. They found that attractive bike areas can deflect some use from illegally used bike trails in core zones of the Biosphere Reserve.

However, regarding the conflicts between hikers and bikers and respective mitigation measures, studies investigating the effect and success of such strategies on the long-term are scarce and have been lacking for the specific context of urban forests.

1.2. Research objectives

The first objective of the study was to investigate – with a case study – if a mixture of measures to reduce disturbances between bikers and hikers can be effective in the long term.

Additional information about the group of bikers was collected. The long-lasting effect of the package of measures should also be considered individually for each user group (hikers, bikers and people who hike and bike), as these could differ in terms of perception and acceptance of the measures.

Based on theories and existing literature, the study focuses on two questions.

1. Can a use concept as it was introduced in the study area in 2005 lead to a sustained reduction in the frequency of disturbance?
2. Do the measures show a positive reducing effect on the perceived frequency of disturbances for all user groups?

2. Methods

An experimental design was chosen to control the effects of the measures on perceptions of conflict, as well as on the perception of other users' attitudes and behaviour. Between 2005 and 2006 a panel designed pre-post survey was conducted; for the third survey (2017), a new sample was drawn because the panel mortality would have been too large after 11 years.

By combining the panel survey (2005/2006) and cross-sectional survey (2017), data from three points in time could be used to make statements about longer-term trends in the area.

2.1. Study area Uetliberg

The study area Uetliberg (Fig. 1), a forested mountain of Zurich, is a popular recreation area for hikers and bikers. It is well served by a rail link from the nearby city centre and attracts further activity groups than bikers and hikers, e.g., joggers, families, and tourists. The forest is open to the public and offers a variety of infrastructure such as picnic areas and playgrounds, restaurants, and viewpoints.

Due to increasing frequentation, conflicts between different recreation users (Annighöfer et al., 2014), especially between bikers and hikers, occurred in the study area. A strategy developed by the responsible authority "Grün Stadt Zürich" should reduce these conflicts and ensure visitor satisfaction. The strategy consisted of a broad management package that included, e.g., the closure of undesirable trails, the construction of a legal single-bike trail, round tables with stakeholders, the charter "Hiking and Cycling on the Uetliberg", the prohibition of bicycle transport for the last part of the train route to the top of Uetliberg, the improvement of signposting, and temporal controls on forest roads and paths with a cycling ban (Tschannen et al., 2015). Between 2006 and 2017 the study area and the sport of mountain biking developed further, measures in the study area have been adapted, for example

Fig. 1. Study area & city of Zurich: https://www.maps.stadt-zuerich.ch, self-edited.

the bike trail was structurally changed and carrying bikes on the track was temporarily fined (Knuser et al., 2017; Tschannen et al., 2015).

2.1.1. Legal situation in the study area

By Swiss law, bikers are not allowed to ride on forest paths that are not suitable for bicycles or are obviously not intended for this purpose, such as footpaths and hiking trails (SVG, SR 741.01).

For hikers, on the other hand, access to the Swiss forest is largely free (ZGB, Art. 699 Abs. 1). There is a general ban on driving motor vehicles on forest roads in Switzerland (WaG, Art. 15, LS 921.0). Excluded from this ban are e-bikes without (structural max. speed 20 km/h) and with pedal assistance (structural max. speed 25 km/h) (SR, Art. 19 Abs. 1 lit. c). At the cantonal level, it is additionally stated that cycling in the forest is only permitted on roads and paths (KaWaG, LS 921.1, §6), but not on beaten tracks and maintenance corridors (KWaV, LS 921.11, §2) and exceptions are regulated by the municipality (KaWaG, LS 921.1, §6).

In reality, however, biking can only be prohibited to a limited extent, and a lack of or insufficient public infrastructure can lead to bikers illegally using hiking trails (Koemle & Morawetz, 2016) or building trails on their own without permission (Zajc & Berzelak, 2016). This in turn can lead to conflicts with other actors in the forest.

2.2. Visitor surveys

2.2.1. Questionnaires

All questionnaires (2005, 2006 and 2017) contained general questions about mode of travel, type and frequency of activity and questions about the sociodemographic background. Subsequently, items of perceived quality of the recreation experience, perceived risk, behaviour, and attributions regarding other forest visitors were recorded. The frequency of disturbance caused by bikers and caused by other activities were asked. Questions concerning the above-mentioned management measures (bike trail, transport ban etc.) were only asked in the second and third survey. Questionnaires from the literature on recreational use served as models for operationalizing the items (Bernath, 2006; Bowker & English, 2002; Franzen, 1999; Graefe & Thapa, 2004; Wild-Eck, 2003; Zeidenitz, 2005).

2.2.1.1. Measurements: most relevant item scales in the questionnaire.

Tolerance, conformity to rules, considerateness, perceived danger, and *degree of familiarity* are factors relevant to the rise of conflict. The extend of these **conflict relevant factors** are measured by agreement with the statements: "Others are tolerant" "Willingness to follow rules has decreased" "I don't care if others are disturbed by my recreational activities" "Sometimes bikers endanger other forest visitors" and "I know many other visitors at least by sight" on a five-point answer scale (0) *strongly disagree* to (4) *strongly agree.*

Acceptance was measured by agreement to statements on a five-point answer scale (0) *strongly disagree* to (4) *strongly agree*: "There are too many signs in the forest at Uetliberg" "I find it acceptable that bicycles are not allowed to be transported by train between Waldegg and Uetliberg" "I find it acceptable that cycling is allowed on almost all wide forest roads" "I welcome the fact that the Triemli bike trail has been created as a legal descent for bikers".

The **frequency of disturbance** was determined by answering on a five-point answer scale (0) *never* to (4) *very often* to the question "How often were you disturbed by the following actors (hikers, bikers on trails or forest roads, e-bikers on trails or forest roads) on the Uetliberg in the last year?"

In the first and second survey 2005 and 2006 only the general *frequency of disturbances caused by biking* was asked and answered on a five-point answer scale (0) *never* to (4) *very often.* In the third survey 2017 the perceived *frequency of disturbances caused by biking* was asked separately *on trails* and *on forest roads* and answered on the same scale than in the previous questionnaires ((0) *never* to (4) *very often*). For comparison the

two variables had to be combined and four coding solutions with different content assumptions were tested. All coding-solutions showed a further reduction in the frequency of disturbance due to biking from 2006 to 2017 for the total sample. The chosen assumption was convincing in terms of content and did not promise a false-positive answer to the research questions.

The **visitor satisfaction** regarding the recreation area in general and the behaviour of other area visitors was measured following the importance-performance analysis. Four questions regarding the satisfaction and importance were asked and answered on a six-point answer scale (0) *absolutely unimportant/unsatisfied* to (5) *absolutely important/satisfied*: How important is the Uetliberg to you as a recreational area?" "How satisfied are you with the Uetliberg as a recreational area?" "How important is the behaviour of other users to you?" "How satisfied are you with the behaviour of other users?" Regarding the theory satisfaction should be at the same or higher level than importance that we can speak of a good quality (Askew et al., 2017).

2.2.2. Data collection

Measurements were taken through surveys at three points in time prior to the implementation of the measures (2005), after an impact period of approximately 1.5 years (fall 2006) and 12 years (summer 2017). In total, 1293 responses from 985 visitors (biking and/or hiking) were included in the study.

2.2.2.1. Panel design. Two surveys were conducted based on a panel design, before the implementation of the measures (2005) and after an impact period (2006). For the first survey, questionnaires with response envelopes were distributed at three locations in the study area. For the second survey, the questionnaire was sent by mail to all participants of the first survey. In 2005, 49% of the distributed questionnaires (n = 491) were answered and could be used for the study. Of these individuals reached in the first wave, 63% (n = 308) participated again in the second survey and were included in the evaluation.

2.2.2.2. Cross-sectional design. As in the first survey we used an opportunity sample for the 2017 sample. In three locations in the study area forest visitors who were found hiking or biking were approached and asked if they are willing to fill in the questionnaire. The survey could be answered on paper on site or later and returned with a prepaid envelope or answered directly per link online. In addition, a local kiosk had the surveys available, and the local bike club informed its members about the survey. The questionnaire could be completed online and by post from 06.07 to August 20, 2017. Of the 748 questionnaires distributed 494 surveys, 398 returned in paper form and 96 completed online, could finally be analysed (66% response rate).

2.3. Statistical analysis

The paper questionnaires were scanned for statistical analysis using the OCR programme Remark and coded and checked for statistical analysis with IBM SPSS 22. A general descriptive statistic was used to describe the socio-demography and characteristics of the recreational users. Three user groups were formed: *hikers* = hike but don't bike, *polysportives* = bike and hike and *bikers* = bike but don't hike. The data from every year 2005/2006/2017 was treated as an independent sample. If the groups examined were smaller than 30, a normal distribution was not assumed and the Mann-Whitney test (for two groups) or the Kruskal-Wallis test (for more than two groups) was used to test for differences. If the groups were larger than 30 the comparison of relevant items was carried out using (Welch's-) Anova when comparing three groups and comparing two groups using (Welch-)T-tests.

3. Results

3.1. Characteristics of the survey samples

The catchment area was concentrated in the canton of Zurich and at all three survey times most respondents lived in the city of Zurich. The largest user group was *hikers*, followed by *polysportives* and *bikers* (Table 1). The survey in 2017 showed the bikers in the study area used mainly All mountain or Enduro bikes followed by Cross country and Freeride bikes. The proportion of women in all user groups has remained the same over time; due to the higher number of bikers, there are fewer women in the 2017 sample than in 2005/2006, $\chi(2) = 10.67$, $p = .005$. There are differences between the samples in terms of age $F(466.12) = 13.03$, $p = .000$, we noticed a lower mean age for *hikers* in the 2017 sample than 2005 ($p = .000$) and 2006 ($p = .000$).

The age of the respondents ranged from 12 to 93 years; the average age was 48 years. *Hikers* were the oldest user group (Fig. 2 and Table 1); *bikers* were younger on average than *hikers* and *polysportives*. Nearly one third of *bikers* were between 30 and 35 years old, and the majority of *hikers* were above 50 years old.

3.2. Acceptance of interventions

Compared to 2006 directly after the measures, the acceptance of the transport ban for bikes was lower in 2017. The number of signs in the forest appeared less often to be too large, and the acceptance of the driving permit for bikers on most wide forest roads had increased, whereas the acceptance of the bike trail did not change (Fig. 3).

Looking at the acceptance of the measures and their evolution among the user groups, differences become apparent. The ban met with greater approval by *hikers* than by *polysportives* and *bikers* ($F(2, 278.99) = 19.31$, $p = .000$), but was less accepted by all user groups in 2017 than in 2006 (Fig. 3 and Table 2). The number of signs was more appropriate for *hikers* than for the other user groups, $F(2, 284.70) = 14.92$, $p = .000$. Dissatisfaction with the number of signs decreased significantly from 2006 to 2017 for *bikers* and *hikers* (Table 2).

The Triemli bike trail was more accepted by *bikers* and *polysportives* than by *hikers* $F(2, 326.64) = 12.03$, $p = .000$. The satisfaction with the existence of the bike trail decreased among *hikers* from 2006 to 2017, while it increased among *polysportives*, and no significant change was found among *bikers* (Table 2). *Hikers* showed the lowest acceptance of riding permits on wide forest trails, $F(2, 334.29 = 85.25$, $p = .000$.

3.3. Conflict-relevant perception of other recreational actors

The perceived risk from bikers decreased from 2005 to 2006 and in the long term to 2017 significantly (Table 3 and Fig. 4). It had decreased for *hikers* compared to 2005/2006 and for *bikers* compared to 2005 before the implementation of the measures, while it had stagnated at 2006 levels for *polysportives*. In 2017, the agreement with the statement "*willingness to follow the rules had decreased*" was lower than in 2005/2006 and others were perceived as less tolerant than in 2005/2006 (Fig. 4).

No significant change in the assessed tolerance of others was found among individual user groups. *Hikers*, polysportives (compared to 2005/2006) and bikers (compared to 2005) were less likely to agree that there was a declining willingness to follow rules in 2017 (Table 3).

Overall, *hikers* rated tolerance of other visitors higher than *polysportives* and *bikers, F(2, 359.20) = 10.07, p = .000. Polysportives* were more likely than *bikers*, but less likely than *hikers*, to believe that willingness to follow rules has decreased, $F(2, 382.23) = 53.96$, $p = .000$. *Hikers* were the user group that felt most endangered from bikers, $F(2, 363.24) = 97.04$, $p = .000$ (Table 3).

Table 1
Characteristics, differences between the user groups (χ2-, Kruskal-wallis, (Welch's-) Anova Test.

Items	Year	All users		Bikers		Hikers		Polysportives		Test
		Share	*N*	Share	*N*	Share	*N*	Share	*N*	
Overall Sample	2005	**100%**	**491**	4.9%	24	72.5%	356	22.6%	111	$\chi(4) = 112.60$, $p \leq .001$
	2006	**100%**	**308**	5.5%	17	71.4%	220	23.1%	71	
	2017	**100%**	**494**	21.3%	105	46.6%	230	32.2%	159	
	total replies	**100%**	**1293**	11.3%	146	62.3%	806	26.4%	341	
Women	2005	**44.5%**	**458**	20.8% a	5	53.2% b	173	23.9% a	26	$\chi(2) = 34.28$, $p \leq .001$
	2006	**44.2%**	**301**	17.6% a	3	53.7% b	115	21.4% a	15	$\chi(2) = 24.47$, $p \leq .001$
	2017	**35.0%**	**490**	16.5% a	17	55.3% b	126	18.2% a	29	$\chi(2) = 76.17$, $p \leq .001$
	total replies	**40.8%**	**1249**	17.4% a	25	54.0% b	414	20.7% c	70	$\chi(2, 144.42)$, $p \leq .001$
Residents of the city of Zurich	2005	**69.3%**	**420**	68.2%	15	69.2%	206	69.7%	68	$\chi(2, 0.21)$, $p = 1.00$
	2006	**67.5%**	**308**	58.8%	10	68.6%	151	66.2%	47	$\chi(2, 0.77)$, $p = .68$
	2017	**72.3%**	**481**	60.4% a	61	76.5% b	169	74.2% b	118	$\chi(2, 9.37)$, $p \leq .01$
	total replies	**70.1%**	**1209**	61.4% a	86	71.2% b	525	71.1% b	232	$\chi(2, 5.62)$, $p = .06$
⌀ Age		**Years**	***N***	Years	*N*	Years	*N*	Years	*N*	
	2005	**52.0**	**449**	35.5 a	21	56.4 b	321	42.2 a	107	$H(2) = 83.65$, $p \leq .001$
	2006	**54.0**	**296**	36.4 a	16	58.3 b	211	44.8 a	69	$H(2) = 54.83$, $p \leq .001$
	2017	**44.8**	**487**	36.1 a	101	50.8 b	227	41.7 c	159	$F(2, 293.52) = 49.55$, $p \leq .001$
	Total replies	**49.6**	**1232**	36.0 a	138	55.3 b	335	42.5 c	759	$F(2, 418.60) = 197.75$, $p \leq .001$

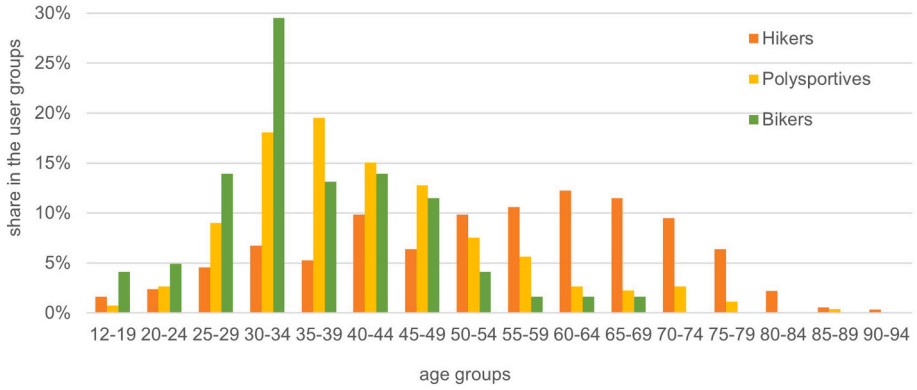

Fig. 2. Age of the user groups (1. and 3. survey, respondents n = 936).

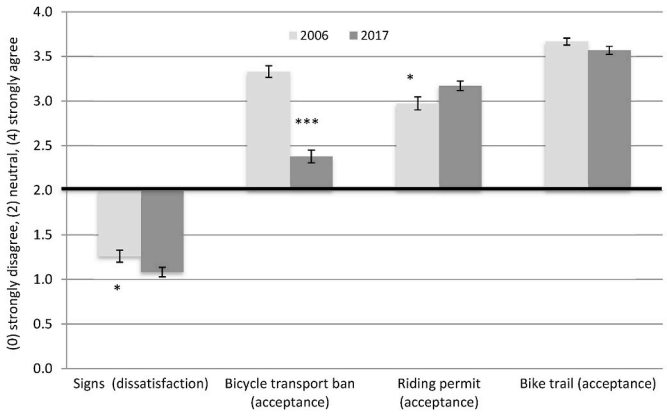

Fig. 3. Mean measures acceptance/dissatisfaction (±SE) in 2006 and 2017. (Welch-)T-test, pairwise case exclusion. 2006: n = 281–299, 2017: n = 489–491. significance. *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$.

3.4. Perceived general conflict level

The goal of the management measures taken in 2005 to reduce conflicts caused by biking could be achieved for all three user groups. The proportion of people who experienced disturbances caused by bikers at all, decreased in time. In 2017, 46% of all users (and 66% of *hikers*) experienced disturbances due to biking, which was a smaller proportion than at the previous survey times in 2005 (90% of all users and 96% of *hikers*) and 2006 (71% of all users and 84% of *hikers*).

Not only decreased the frequency of disturbance due to bikers, but also the frequency of disturbance due to *hikers*. Only for *polysportives* the frequency of disturbances due to hiking increased slightly again from a low level and was in 2017 at the same level as in 2005, before the measures were initialized (Fig. 5 and Table 4). Overall the data shows that *bikers* perceived more disturbances due to hikers than *hikers* and *polysportives* and *polysportives* more than *hikers*, $F(2, 337.46) = 18.80$, $p = .000$. On the other hand, *hikers* perceived more disturbances due to bikers than *polysportives* and *bikers* and *polysportives* more than *bikers* $F(2, 407.00) = 157.54$, $p = .000$ (Fig. 6).

3.5. Visitor satisfaction

The importance attributed to as well as the satisfaction with the recreation area Uetliberg was at a high level at all three time points (Fig. 7). The attributed importance of *the recreation area* and *the behaviour of other visitors* decreased from 2006 to 2017 (Table 5). In 2017, different to 2005 and 2006, for the overall sample there was no under-quality in the assessment of the recreation area and the behaviour of other visitors. *Polysportives* showed a small under-quality regarding the *recreation area*, *hikers* regarding the *behaviour of other users* in 2017. *Bikers* assigned less importance to the recreation area and in 2017 they were less satisfied with it than the other users (Table 6, Table 7).

4. Discussion

4.1. Limitations

Some limitations regarding the study design and methodology are important for the applicability of the case study. Due to the survey

Table 2
Comparison between 2006 and 2017 regarding the average acceptance/dissatisfaction with the measures per user group. Table shows means, test-values and significance levels.

Items		*M*		Test
		2006	2017	
Signs (dissatisfaction)	Bikers (N = 119)	1.93	1.20	Z = −2.23, $p \leq .05$
	Hikers (N = 423)	1.14	0.77	t(421) = 3.60, $p \leq .001$
	Polysportives (N = 228)	1.45	1.44	t(226) = 0.05, $p = .959$
	All (N = 770)	1.26	1.08	t(768) = 2.04, $p \leq .05$
Bicycle transport ban in the train (acceptance)	Bikers (N = 120)	2.88	2.04	Z = −2.08, $p \leq .05$
	Hikers (N = 430)	3.38	2.69	t(415.26) = 6.00, $p \leq .001$
	Polysportives (N = 230)	3.28	2.16	t(188.06) = 5.73, $p \leq .001$
	All (N = 780)	3.33	2.38	t(753.42) = 9.91, $p \leq .001$
Riding permit on wide forest roads (acceptance)	Bikers (N = 121)	3.59	3.62	Z = −0.52, $p = .606$
	Hikers (N = 436)	2.64	2.67	t(434) = −0.25, $p = .804$
	Polysportives (N = 229)	3.80	3.61	t(196.00) = 2.00, $p \leq .05$
	All (N = 786)	2.97	3.17	t(784) = -2.22, $p \leq .05$
Bike trail "Triemli" (acceptance)	Bikers (N = 121)	3.59	3.73	Z = −1.79, $p = .073$
	Hikers (N = 439)	3.68	3.30	t(373.85) = 4.23, $p \leq .001$
	Polysportives (N = 230)	3.65	3.85	t(120.91) = -2.09, $p \leq .05$
	All (N = 790)	3.67	3.57	t(772.19) = 1.64, $p = .102$

design and the survey area chosen, we did not reach user groups that were displaced from the area, such as downhillers, as well as bikers who prefer flat forest trails. We wanted to know where biking causes disturbance, and in 2017 we asked not only about the general frequency of disturbance caused by biking, as in the first and second surveys, but also about the frequency of disturbance caused by biking on forest roads and trails. For comparison with the previous surveys, the two variables had to be combined. For this purpose, four codings with different content assumptions were tested and the best one was selected (see 2.2.1 and Appendix). All codings showed a further reduction in disturbance frequency due to biking from 2006 to 2017 for the total sample as the main effect. For none of the codings did the disturbance frequency increase since 2006 for hikers, polysportives or bikers, so that the statement that there has been a sustained reduction in disturbance since the introduction of the measures is reliable.

A combination of panel (2005/2006) and cross-sectional (2017) surveys was used, with each year treated as an independent sample. This was to allow for a trend study and to ensure minimal data loss. The change in survey design may have resulted in differences (e.g., in attitudes and values) between samples. To highlight existing differences where possible, sociodemographic data from 2005, 2006, and 2017 were compared. To avoid erroneous conclusions due to the combination of panel design and cross-sectional surveys, the main statements from 2005 to 2006 were additionally tested with a paired *t*-test. The comparison with the (Welch'-s) Anova results showed that the main statements of the study were not affected.

4.2. Findings

This research contributes to a better understanding of disturbances between *bikers* and *hikers* in urban recreation areas and to an assessment of the effect of mitigation strategies. The study confirms the positive benefits of visitor management through hard and soft measures. It shows that the acceptance of measures, as well as the satisfaction with the recreation area and the behaviour of other users was high not only in the short term after implementation (2006), but also in the longer term (2017).

The main objective of the study, the reduction of conflicts between *bikers* and *hikers*, was achieved; over the three survey periods there is a clear trend towards a reduction in the frequency of disturbances.

This study was carried out in an urban forest with steep up and downhill sections providing an official bike trail. Compared to the average Swiss mountain biker, the bikers found in the study area were younger and more often male. But overall the socio-demographic structure of *bikers* and *hikers* is comparable to other studies (e.g. Koemle & Morawetz, 2016; Krämer et al., 2004; Pickering & Rossi,

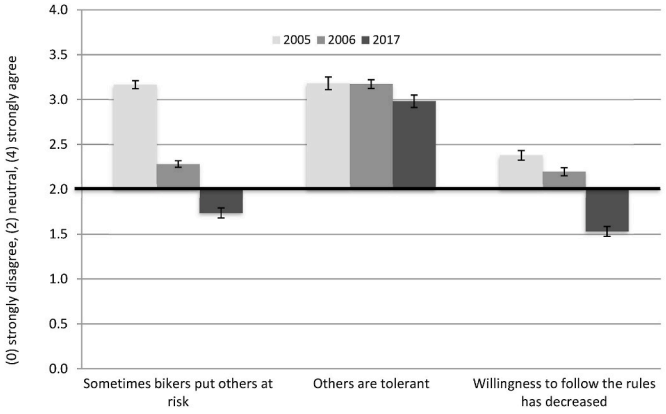

Fig. 4. (Welch's-) Anova on differences in conflict relevant items scores at the three survey time points. Pairwise case exclusion. 2005: n = 467–482, 2006: n = 283–286, 2017: n = 486–489.

Table 3
Comparison of conflict relevant factors between the time points for the user groups hikers and polysportives. (Welch's-) Anova, bikers Kruskal-Wallis test.

Items		*M*	2005 (n = 478–500)	2006 (n = 291–297)	2017 (n = 491–494)	(Welch's-) Anova/Kruskal-Wallis-Test
Sometimes bikers put other at risk	Bikers	1.45	2.63 a	1.71 ab	1.14 b	H(2) = 25.81, $p \leq .001$
	Hikers	2.76	3.36 a	2.49 b	2.08 c	F(2, 407.37) = 122.59, $p \leq .001$
	Polysportives	2.01	2.65 a	1.83 b	1.65 b	F(2, 179.97) = 25.07, $p \leq .001$
	All	2.41	3.17 a	2.28 b	1.74 c	F(2, 713.12) = 214.09, $p \leq .001$
Other forest visitors are tolerant	Bikers	2.83	3.00	3.06	2.75	H(2) = 2.68 $p = .262$
	Hikers	3.18	3.21	3.21	3.12	F(2, 443.74) = 0.85, $p = .429$
	Polysportives	3.04	3.14	3.09	2.94	F(2, 181.06) = 1.73, $p = .18$
	All	3.10	3.18 a	3.17 a	2.98 b	F(2, 741.27) = 6.94, $p \leq .01$
Willingness to follow the rules has decreased	Bikers	1.38	1.74 a	1.94 ab	1.21 b	H(2) = 10.58, $p \leq .01$
	Hikers	2.27	2.51 a	2.36 a	1.82 b	F(2, 451.37) = 23.37, $p = .429$
	Polysportives	1.68	2.09 a	1.79 a	1.34 b	F(2, 181.94) = 13.58, $p \leq .001$
	All	2.00	2.38 a	2.20 a	1.53 b	F(2, 732.81) = 64.81, $p \leq .001$

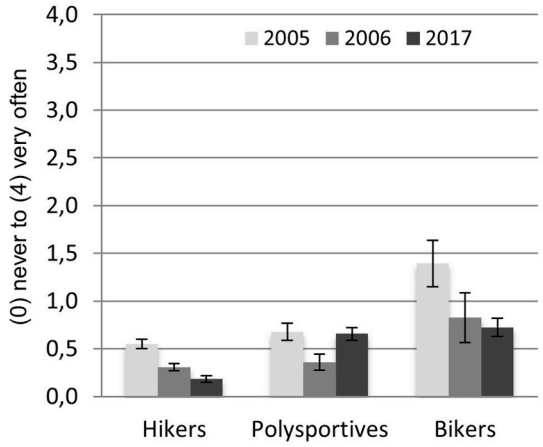

Fig. 5. Perceived frequency of disturbances due to hikers per year and user group (mean, se).

2016; Zajc & Berzelak, 2016) mainly young till middle aged men were biking and on the other hand woman and man in the same range, nearly of every age were hiking.

Conflict relevant factors differ between the user groups. *Hikers* felt more put at risk by bikers but perceived the tolerance of other visitor as higher than *polysportives* and *bikers* did. *Polysportives* agreed more than *bikers* but less than *hikers* that the willingness to follow the rules has decreased. The asymmetric conflict relationship between *bikers* and *hikers* found in other recreational conflict studies (Carothers et al., 2001; Mann & Absher, 2008; Pickering & Rossi, 2016) existed in the study area as well, as the conflict between the activity groups was perceived more strongly by *hikers*. *Polysportives* (people who bike and hike) as also described by Carothers et al. (2001), reported less disturbances due to both *bikers* and *hikers* than pure *hikers* and pure *bikers* experienced due to each other's activities.

Polysportives have experience with both activities and belong to both activity groups. Belonging to both groups, makes it more difficult to perceive an outgroup conflict (Graefe & Thapa, 2004). The results show that not only *bikers*, but also *polysportives* perceive bikers less as a risk than walkers. This supports the findings of previous studies, e.g., Cessford (2003) and Horn (1994, p. 158), that greater experience with bicycling reduces the perceived risk posed by bikers.

The value of both attributes behaviour and area quality was high at all three time points. In the longer-term from 2006 to 2017 the importance of behaviour and area decreased, while the satisfaction with the area stagnated and the satisfaction with the behaviour of others increased. The theory of the importance-performance analysis states that satisfaction shouldn't be lower than importance. Expectations higher than performance produce dissatisfaction (Askew et al., 2017) as in 2005 and 2006 when satisfaction was a little bit lower than importance. In 2017, the importance-performance analysis showed a good balance between importance and satisfaction for area and behaviour.

In the following, the two research questions are evaluated:

1. Does a use concept like it was introduced in the study area lead to a sustained reduction in the frequency of disturbances?

This study compared perceptions of conflicts due to bikers and hikers immediately before and after the implementation of visitor management measures as well as eleven years after. One objective was to investigate whether the package of measures applied in the study area reduced conflicts between bikers and hikers in the long term. The study shows that a broad mix of measures can succeed in mitigating biker-hiker conflicts. Disturbances in the study area were decreasing from 2005 to 2006 and in longer time to 2017, so they are rather rare in 2017.

In the study area, the acceptance of soft and hard measures differed.

Table 4
Mean frequency of disturbances due to *hikers* and *bikers* for the user groups at the three survey times (0) *never*, (4) *very often*, (Welch's-) Anova *hikers* and *polysportives*, Kruskal-Wallis *bikers*.

User group	Disturbed by		*N*	*M*	*WELCH-F test/* Kruskal-Wallis-test	Significance
Hikers	Hikers	2005	337	0.55 a	F(2, 494.27) = 18.04	$p \leq .001$
		2006	198	0.31 b		
		2017	225	0.18 c		
	Bikers	2005	318	2.45 a	F(2, 442.52) = 65.73	$p \leq .001$
		2006	194	1.54 b		
		2017	219	1.43 b		
Polysportives	Hikers	2005	108	0.68 a	F(2, 185.06) = 4.72	$p \leq .01$
		2006	70	0.36 b		
		2017	157	0.66 a		
	Bikers	2005	109	1.38 a	F(2, 176.59) = 17.73	$p \leq .001$
		2006	69	0.70 b		
		2017	157	0.61 b		
Bikers	Hikers	2005	23	1.39 a	H(2)8.63	$p \leq .05$
		2006	17	0.82 ab		
		2017	105	0.72 b		
	Bikers	2005	24	1.46 a	H(2)36.41	p ≤ .001
		2006	17	0.59 b		
		2017	104	0.25 c		
All	Hikers	2005	482	0.62 a	F(2, 778.75) = 10.84	$p \leq .001$
		2006	293	0.35 b		
		2017	492	0.45 b		
	Bikers	2005	464	2.14 a	F(2, 731.89) = 124.06	$p \leq .001$
		2006	289	1.28 b		
		2017	484	0.93 c		

Overall, the transport ban for bicycles as a hard measure was less accepted than the soft measure dealing with infrastructure supply (opening forest roads for bikers and the Triemli bike trail) by all user groups. Presumably due to the temporary introduction of fines, the transport ban was less accepted by all user groups in 2017 compared to 2006. This is not surprising, as in the literature rules, constraints and fines are considered to potentially reduce quality (Moore, 1994; Opaschowski, 2006; Zeidenitz, 2005). The vast majority of users assesses the construction of the Triemli bike trail positively or neutral; this is not self-evident, as shown by a nationwide Swiss study (Hunziker et al., 2012) in which more than half of the respondents were bothered by bike trails. Through information attitudes can be changed – as explained in the studies of Marion and Reid (2007) and Mosler and Tobias (2007) – and conflict perceptions reduced - as shown in a study written by Cessford (2003). In the present study after the introduction of the measures, bikers were less perceived as putting others at risk and all

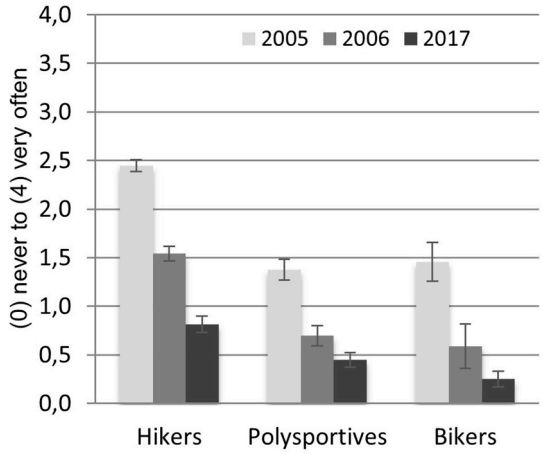

Fig. 6. Perceived frequency of disturbances due to bikers per year and user group (mean, se).

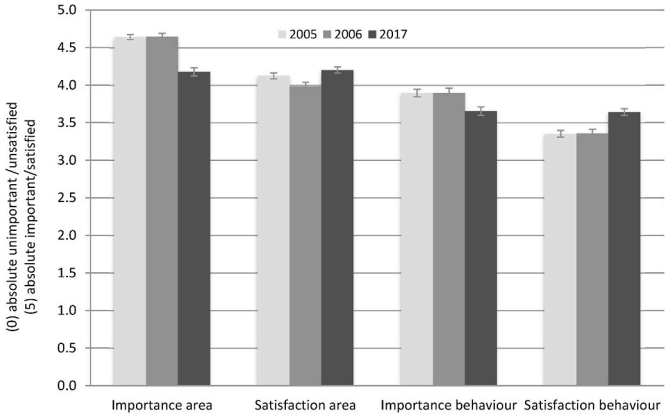

Fig. 7. Importance-performance analysis of the recreation area and the behaviour of other users, in 2005: n = 478–479, 2006: n = 290–291, 2017: n = 490–492.

Table 5
(Welch's-) Anova differences in time for importance and satisfaction, answer scale: 0 = *absolutely unimportant/unsatisfied*, 5 = *absolutely important/satisfied*.

	Area				Behaviour of others			
	Importance		Satisfaction		Importance		Satisfaction	
	M	SD	M	SD	M	SD	M	SD
2005	4.64 a	.732	4.12 ab	.886	3.90 a	1.103	3.35 a	.959
2006	4.64 a	.789	3.98 a	.944	3.90 a	1.098	3.36 a	.946
2017	4.18 b	1.17	4.20 b	.923	3.65 b	1.256	3.64 b	.977
F	30.49		4.90		6.15		13.22	
$p \leq$	.001		.01		.01		.001	

respondents believed less that non-compliant behaviour has increased. Arguably, the shared infrastructure also provided space for positive interactions and the reduction of prejudices, as Moore (1994) describes, this is a positive factor for the reduction of conflicts.

2. Do the measures show a reducing effect on the perceived frequency of disturbances for all user groups?

The long-lasting effect of the measures on the perceived frequency of disturbances is shown individually for each user group (hikers, bikers and people who hike and bike). The frequency of disturbances due to bikers decreased for each user group on short- and longer-term. Disturbance's due to *hikers* decreased ingroup for the *hikers* and as well outgroup for the *bikers*. As found in other studies (Carothers et al., 2001; Mann & Absher, 2008; Vaske et al., 2000) there were significantly fewer conflicts within an activity than between activities, nevertheless also this rare ingroup conflicts were further reduced by the measures.

It was analysed and confirmed that the user groups differ in terms of perception and acceptance of the measures. *Bikers* and *polysportives* showed a higher preference for bike infrastructure (opening of wide forest roads and building of the bike trail Triemli) than *hikers*. *Hikers* rated the restrictive measure for bikers (the ban for transporting bikes on the train) more positive than people who bike. They also seem to prefer more signs than *bikers* and *polysportives*.

The study confirms previous research (Immoos & Hunziker, 2014; Manning & Anderson, 2012) that a mix of hard and soft measures can reduce disturbances from outdoor activities. The sustained reduction of social conflicts between *bikers* and *hikers* in the study area shows that such a package of measures can be effective in the long-term. In line with this, the level of satisfaction showed 2017 is high and indicates that the management is working well regarding behaviour of visitors and the recreation area Uetliberg in general.

During the first phase of the pandemic (2020) there were severe restrictions. Individual outdoor sports such as mountain biking and hiking were still possible while gyms were closed, and cultural and group activities were restricted. A recent study (Wunderlich et al., 2021) showed the changing of the pattern of forest visits in Switzerland during this phase - the duration of forest visits became shorter, and many people visited the forest less frequently as before the pandemic. But especially people who worked in a home office were more often in the forest (Wunderlich et al., 2021) and did more sports than before (Füzéki et al., 2021). Through home offices, leisure users are more flexible in their time management. This can be used by intelligent visitor management (e.g., public information about visitor peaks). If the number of recreational users increases due to the home office, this will probably increase the potential for conflict between mountain bikers and hikers.

5. Concluding management implications and future research

In agreement with Moore (1994), Pickering and Rossi (2016), Arnberger and Haider (2007), Koemle and Morawetz (2016), Cessford (2003), and Reichhart and Arnberger (2010) it can be concluded from the results that under certain physical, spatial and social conditions, shared use of trails is accepted by users and a reasonable choice to avoid trail infrastructure in near-natural areas. However, as overtaking manoeuvres and high speeds lead to conflicts, it seems necessary to separate steep downhill trails especially in heavily used recreation areas for bikers and hikers.

The study shows that hard measures are less accepted by the groups affected than soft measures. Nevertheless, they can be important and show acceptance and effect in combination with different spatial and communicative measures. If possible, measures should be developed in consultation with stakeholders and be accompanied by a regular visitor monitoring not only analysing the acceptance of the measures but also ensure actual effects of mitigation measures on attitudes and behaviour of the target groups to ensure a lasting impact.

Due to the increasing number of city inhabitants and rising urban summer heat, more people will use the forest seeking lower temperatures and recreation. In addition, new user groups such as e-bikers may cause further social and environmental conflicts in the forest. For e-bikers, attitudes and behaviours need to be identified and additional adapted measures may need to be taken.

Therefore, effective measures and close monitoring, including counting the different users in the forest, are important to maintain recreational quality and natural space.

Future research efforts should focus on finding appropriate solutions for specific conflict situations. So that visitor management has the right tools at its disposal once a conflict has been identified. In addition, the

Table 6
Importance-performance analysis for the recreation area, differences between the user groups, answer scale: 0 = *absolutely unimportant/unsatisfied*, 5 = *absolutely important/satisfied*.

		Area					
		Importance			Satisfaction		
		Hikers	Polysportives	Bikers	Hikers	Polysportives	Bikers
2005	*N*	345	110	24	345	110	24
	M	4.66 a	4.67 a	4.25 b	4.11	4.15	4.13
	SD	0.76	0.58	0.85	0.93	0.80	0.61
Kruskal-Wallis-test		H(2)9.84; $p = .007$			H(2).28; $p = .871$		
2006	*N*	205	70	16	205	70	16
	M	4.69 a	4.67 a	4.00 b	4.00	3.90	4.13
	SD	0.78	0.66	1.10	0.95	0.92	0.96
Kruskal-Wallis-test		H(2)12.65; $p = .002$			H(2)1.58; $p = .454$		
2017	*N*	229	159	104	228	159	103
	M	4.34 a	4.26 a	3.69 b	4.38 a	4.18 b	3.83 c
	SD	1.09	1.04	1.41	0.81	0.84	1.15
Welch's Anova		F(2,244.88) = 8.79; $p = .000$			F(2,237.21) = 10.31; $p = .000$		

Table 7
Importance-performance analysis for behaviour of other forest visitors' differences between user groups, answer scale: 0 = absolutely unimportant/unsatisfied, 5 = absolutely important/satisfied.

		Behaviour of other vistors					
		Importance			Satisfaction		
		Hikers	Polysportives	Bikers	Hikers	Polysportives	Bikers
2005	*N*	344	110	24	344	110	24
	M	4.03 a	3.58 b	3.46 b	3.34	3.46	3.04
	SD	1.08	1.13	0.93	0.98	0.91	0.91
Kruskal-Wallis-test		H(2) 22.36; $p = .000$			H(2)4.01; $p = .135$		
2006	*N*	204	70	16	204	70	16
	M	4.00	3.70	3.50	3.28	3.53	3.50
	SD	1.10	1.04	1.10	0.99	0.76	1.03
Kruskal-Wallis-test		H(2)8.17; $p = .017$			H(2)2.97; $p = .226$		
2017	*N*	227	159	104	227	159	104
	M	3.73	3.62	3.53	3.61	3.71	3.61
	SD	1.29	1.18	1.28	1.00	0.83	1.13
Welch's Anova		F(2,262.90) = 0.96; $p = .386$			F(2,252.89) = 0.70; $p = .496$		

different mountain biking subgroups and their respective potential for social conflict should be studied in more detail.

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CRediT authorship contribution statement

Annick Kleiner: Conceptualization, Investigation, Formal analysis, Writing – original draft. **Benjamin Wanja Freuler:** Conceptualization, Methodology, Investigation. **Arne Arnberger:** Supervision, Conceptualization, Review & editing. **Marcel Hunziker:** Conceptualization, Supervision, Project administration, Funding acquisition, Methodology, Writing – review & editing.

APPENDIX

Table 8
(appendix): The tested assumptions for the coding of "disturbance frequency due to biking"

Assumption	Description of the assumption
1	The "disturbance frequency due to biking" results from the average of the disturbance frequencies experienced on forest roads and trails. Coding: ("bikers on forest roads" plus "bikers on trails)/2 = "disturbance frequency due to biking".
2	The "disturbance frequency due to biking" is the sum of the disturbance frequency on forest roads and trails. Coding: Bikers on forest roads" plus "Bikers on trails" = "Disturbance frequency due to biking".
3	The higher frequency of disturbance caused by biking on forest paths or trails is decisive. Coding: "disturbance frequency due to biking" = "bikers on forest roads" if "bikers on forest roads" ≥ "bikers on trails" "disturbance frequency due to biking" = "bikers on forest roads" if "bikers on trails" ≥ "bikers on forest roads".
4 (chosen assumption)	The higher fault frequency in each case is decisive, but it is reduced if far fewer faults are perceived on the other infrastructure. If disturbances are perceived with the same frequency on both infrastructures, the disturbance frequency does not add up, but it increases. Coding: If higher value - lower value ≤ 2, then "disturbance frequency due to biking" = higher value. If higher value - lower value > 2, then "disturbance frequency due to biking" = higher value -1. If "bikers on forest roads" ="bikers on trails", then "disturbance frequency due to biking" = value + 1. Except "bikers on forest roads" =" bikers on trails" = 0, then "disturbance frequency due to biking" = 0. Except "bikers on forest roads" =" bikers on trails" = 4, then "disturbance frequency due to biking" = 4

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