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Mountain biking: downhill for the environment or chance to up a gear?

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The paper examines mountain biking as an increasingly popular adventure recreation activity. Some of its extreme derivatives have been incorporated into international events (e.g. Olympics). We review trends in mountain biking, consider the appropriateness of this activity in public natural areas with a conservation mandate (e.g. national parks, nature reserves) and consider alternative locations. We conclude that (1) mountain biking will continue to increase in popularity; and (2) venues developed in rural areas outside of national parks have provided economic benefits to local communities; but (3) the evidence of social conflict with other users and/or environmental impacts is not clear, mainly because of data limitations. Careful management of natural areas designated for recreation and conservation is required as a precautionary approach. Successful models operate outside of national parks that demonstrate a ‘win–win’ solution for stakeholders.

Keywords: Off-road biking; Impacts; Protected area management

Introduction

In recent years, there has been a rise in adventure recreation such as rock climbing, parachute jumping, white-water kayaking and canyoning [1]. Many such activities have also morphed into more extreme versions [2]. There has been a little research into the motivation and perception of participants in these more extreme derivatives compared to the more mainstream versions, but an important element of alternatives appears to be a desire to experience thrills by overcoming (perceived) risks of personal danger [3,4]. Many versions of ‘extreme recreation’ also include competition; for example speed climbing has become an Olympic sport [5]. This changes the mental dynamic of the activity [6].

Most forms of adventure recreation depend on large, public natural areas [7] that are protected by conservation. Technological advances in equipment (e.g. wet suits, ‘flying suits’) and/or navigation aids (e.g. handheld Global Positioning Systems) permit such activities to be undertaken in public natural areas and extend environmental impacts spatially and/or temporally [8,9]. In this paper, we review the adventure recreation activity of mountain biking within the context of off-road cycling, whether recreational or competitive, by local residents or tourists. We discuss (1) market trends in mountain biking; (2) rider profiles; (3) the activity’s potential social conflicts; (4) environmental impacts and associated potential conflicts; (5) reflect on the appropriateness of different types of public

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natural areas for mountain biking; and (6) highlight future research priorities and implications for land use policy-making.

Market trends in mountain biking

Mountain biking as a recreational activity probably originated in Marin County, California, USA during the 1970s [10]. By 2003, approximately 10 million Americans participated [11], and 4–6% of the adult population mountain biked regularly during the period 1994–2003 [12]. Although market development has matured in recent years, mountain/hybrid bikes still represented 44% of unit sales through USA speciality bicycle retailers during 2006–2008 [13].

In other countries, such as Canada [12], New Zealand [14,15] and the UK [16,17], participation in mountain biking continues to grow. For example, more than 2 million bikes were sold in the UK annually and 5.7% of the population were estimated to participate regularly in mountain biking in 2005 [17]. Other nations in which mountain biking is popular include Germany (3.5 million mountain bikers of 7.2 million recreational cyclists) and Switzerland and Austria, with the total number of mountain bikers estimated at 800,000 [12]. In Australia, the number of cyclists grew by 15.3% between 2001 and 2004 [18] and of the 753,843 bikes sold in 2004, 70% were mountain bikes [19]. Although the percentage of such bikes used for off-road riding and their frequency of use are unknown, such data suggest that mountain biking is growing worldwide. For example, the International Mountain Biking Association (IMBA) is now represented in 17 countries including the USA, Australia, Canada, Italy, Mexico, Spain, Netherlands and UK [20], and their code of conduct is considered universal [21].

Like many other forms of adventure recreation (e.g. snow skiing which has morphed into snowboarding, paraskiing and other derivatives), mountain biking has developed new forms. In the traditional form of cross-country/recreational biking, riders use lightweight bicycles to traverse a range of landscapes on rides that typically last a few hours. Emphasis is on relaxation, exercise and appreciation of natural scenery [21] especially on single-track trails where riders are segregated from cars and can enjoy a closer connection with nature [12]. Although cross-country/recreational riding is still the most popular form of the sport (89% USA, 97% UK), more physically challenging, extreme derivatives such as downhill (18% USA, 22.2% UK), freeriding (23% USA, 21.2% UK) and trials (14% USA, 8.1% UK) are growing [11,12,14,16]. Downhill riders descend steep, rough terrain at high speed using heavy, specialist bikes with long-travel suspension. They may wear plastic body armour and full-face helmets for protection, and are transported to the top of the (usually short) runs by ski lifts, 4WD vehicles or helicopter [14,17]. In free-riding (cf. North Shore), the focus is on technical skills needed to handle obstacles such as elevated, narrow wooden boardways, log rides, ladder bridges and teeter-totters, usually on purpose-built circuits [12,14].

Rider profiles

Although there is evidence of a gradual broadening of appeal across gender and age groups, mountain biking remains dominated by young males, who comprise 86% of riders in the USA, 97% in the UK (IMBA members) [11,16] and 85% in Australia (non-IMBA members) [22]. The same studies showed that the typical age was 38 in the USA, 30–39

in the UK and 76% of riders were evenly spread across the 16–44 age group in Australia [11,16,21]. A Scottish study [23] revealed that the average party size of riders was 3, and 15% of visitors cycled with children.

Riders are generally well educated and 39% were in the ‘AB social class’ (i.e. higher managerial, administrative or professional intermediate managerial). Such gender and age profile accords with other adventure recreationists such as rock climbers (e.g. [24]). Detailed information on the demographics, perceptions and motivations of participants among the various forms of mountain biking, and their corresponding requirements is lacking.

Data are especially lacking on participants in the more extreme derivations of the sport (i.e. freestyle, downhill). It is probable, however, that these are skewed towards the younger, more male-dominated riders who seek thrill as the ultimate experience. Such riders would belong to the very large Generation Y demographic (born late 1970s–mid-1990s, currently typically aged 15–30) [25], and will be followed by the emerging Generation Z (those born thereafter). Support for such assertion comes from research showing a high level of interest and/or participation in risk-based forms of recreation and/or sport among these demographics, together with many participants’ desire to rebel against previously accepted norms. They therefore innovate new forms of recreation, often for public display of their personal skill, either informally or as part of formal, competitive events (e.g. [7,24,26]).

Potential social conflicts

Although many recreationists include walking and bike riding in their recreational activities [27], especially in Europe, the potential exists for social conflict between mountain bikers and other trail users, and especially between riders and walkers. Australian research has shown that mountain bikers (predominantly cross-country/recreational surveyed) and walkers recreate outdoors for the same reasons. ‘Relaxation’ (30–57%), ‘exercise’ (65–83%) and ‘appreciation of natural scenery’ (72–82%) are the main benefits sought by both groups [22]. Chiu and Kriwoken [22] also found, however, that 34% of mountain bikers sought ‘excitement and risk’, compared to only 3% of walkers. This suggested that for at least one-third of bikers there is a fundamental difference in motivation between the groups. We predict that the element of thrill-seeking would be most important among participants in the more extreme forms of mountain biking such as downhill. Such riders would be unlikely to have at the forefront of their thinking the ‘Official IMBA Mountain Bike Rules of the Trail’ (see table 1), recognised internationally as the official code [21], or indeed any regional code, since they rely on the IMBA ‘rules’ (e.g. [28,29]), except where the organisation is focused on racing and their codes are most concerned with unacceptable behaviour amongst participants (e.g. officials, athletes) and associated penalties (e.g. [30]).

The IMBA rules of the trail cover conflict between bikers and walkers (see rules 4 and 5, table 1). Such conflict is most likely to occur in peri-urban natural areas. This is because of higher population density and associated greater propensity for encounters. Although there is mutual tolerance [22], shared use of tracks is perceived to be more problematic for walkers. Trail displacement, potential ecological damage and changed environmental experience and safety due to the bikes’ high speed and quietness of approach, are walkers’

Table 1. Official IMBA ‘Mountain Bike Rules of the Trail’ which the IMBA considers that ‘every mountain biker should know and live by ...’.

Rule number	Rule	Background
1	Ride on open trails only	Respect trail and road closures – ask if uncertain; avoid trespassing on private land; obtain permits or other authorisation as may be required. Federal and state wilderness areas are closed to cycling. The way you ride will influence trail management decisions and policies
2	Leave no trace	Be sensitive to the dirt beneath you. Recognise different types of soils and trail construction; practice low-impact cycling. Wet and muddy trails are more vulnerable to damage. When the trail-bed is soft, consider other riding options. This also means staying on existing trails and not creating new ones. Do not cut switchbacks. Be sure to pack out at least as much as you pack in
3	Control your bicycle!	Inattention for even a second can cause problems. Obey all bicycle speed regulations and recommendations
4	Always yield trail	Let your fellow trail users know you are coming. A friendly greeting or bell is considerate and works well; do not startle others. Show your respect when passing by slowing to a walking pace or even stopping. Anticipate other trail users around corners or in blind spots. Yielding means slow down, establish communication, be prepared to stop if necessary and pass safely
5	Never scare animals	All animals are startled by an unannounced approach, a sudden movement, or a loud noise. This can be dangerous for you, others and the animals. Give animals extra room and time to adjust to you. When passing horses use special care and follow directions from the horseback riders – ask if uncertain. Running cattle and disturbing wildlife is a serious offense. Leave gates as you found them, or as marked
6	Plan ahead	Know your equipment, your ability and the area in which you are riding – and prepare accordingly. Be self-sufficient at all times, keep your equipment in good repair and carry necessary supplies for changes in weather or other conditions. A well-executed trip is a satisfaction to you and not a burden to others. Always wear a helmet and appropriate safety gear

Source: IMBA [21].

main concerns [22,31,32]. Despite such concern, collisions between bikers and walkers are apparently rare [15].

Walkers’ perception of bikes as hazards may change with familiarity. In a study of shared-use tracks in New Zealand, Cessford [15] found a difference between walkers’ perceived and actual impacts of bike encounters. Walkers who had encounters with bike riders were more positive about the experience than those who had not had such encounters. Younger walkers also had a more positive attitude towards bikers than older walkers.

Riders did not perceive their activities as having a detrimental impact on other recreationists and most considered that riding should be allowed on all trails. To manage conflict and protect the natural resource, walkers and riders both preferred education-based management policies that are informed by empirical research, rather than more restrictive measures [22]. This is consistent with other studies on outdoor recreation (e.g. canyoning) [1].

Environmental impacts and associated potential conflict

Demand for development of infrastructure to support cycling generally (e.g. [33]), and the various forms of mountain biking specifically (e.g. purpose-built single track trails, uplift facilities for downhill, bike parks for freeriding/trials), is increasing in many countries

[12,34]. In the USA, locations such as Moab (Utah), and Fruita (Colorado) each offer hundreds of kilometres of single track mountain bike trails in desert ecosystems [35,36]. In Canada, alpine resorts such as Whistler Blackcomb offer more than 200 km of trails for mountain biking, including 34 trails of lift-serviced downhill routes. An indication of how important mountain biking has become to such resorts is that summer revenue now represents approximately 75% of winter snow recreation revenue [17,37].

There are potential economic benefits from developing and promoting mountain biking in its various forms. Examples include destination mountain biking tourism [12,17,38] and competitive sporting events, typified by the World Cup Mountain Bike Series [17], Union Cycliste Internationale Mountain Bike and Trials Championship [39]. Mountain biking also provides social networking opportunities and supports a substantial industry in both equipment and clothing (e.g. [40]).

In addition to possible social conflicts, the rising popularity of mountain biking has raised concerns of potential environmental impacts (see [41] for review). The IMBA 'rules' (see rules 1–3, table 1) includes this dimension. Such impacts associated with recreational trails result from their initial design, construction and subsequent use (e.g. type, user behaviour, frequency and intensity) [42,43]. Assessing impacts caused by mountain biking is difficult. Bikers often share trails used by others: for hiking, horse riding and 4WD driving. The specific effects of mountain biking often cannot be readily distinguished [44]. Despite this, instances of the creation of unauthorised, informal bike trails and/or construction of bike-specific infrastructure such as concrete-reinforced jumps and wooden boardways used in freeriding/North Shore are becoming more common, even in protected areas (e.g. [27,45,46]).

On flat terrain under dry conditions, recreational mountain biking impacts on trails, for example increased water runoff, sediment yield and/or soil exposure, together with vegetation and/or species loss, have been found to be comparable with those of walking, and less than those from motorised vehicles or horse riding [22,47]. The severity of impacts depends on climate, slope and other environmental variables. Steep slopes with sparse vegetation and/or fine homogenous soils are most susceptible to damage from biking [10,32].

The greatest impacts usually occur early in trail use, on downhill (braking and skidding) and uphill (wheel spinning) slopes (especially when wet), and on curves (braking and skidding) [10,22,32]. This damage may increase trail incision and/or widening, soil erosion and water runoff. There is little research into the question of use intensity (e.g. under competitive racing conditions) and/or duration. The impact of mountain biking on erosion is, however, cumulative and curvilinear [22]. After rapid initial erosion, the rate of change declines, probably because of increasing soil compaction.

Mountain biking is increasingly popular as a competitive sport. Although the overall level of participation in competitive mountain biking is unknown, members of formal mountain bike clubs are more likely to participate in racing events than non-club members [32]. The impacts from competitive mountain biking probably occur faster and/or are more acute than those from recreational biking. This is because, the essential thrill element of racing demands technically challenging courses, steep up/downhill slopes, fast, hard braking, more intense use, cutting corners, wet sections and the inclusion of jumps/drop offs. Downhill competitive mountain biking events therefore probably pose higher risk of environmental impacts than recreational biking [48].

Australian studies of racing events have found that soil loss at sharp corners is greater than on straight sections [49]. Under wetter conditions there are

increased off-trail vegetation impacts and trail widening, especially on steep slopes and corners. Racing under such conditions also increases off-trail vegetation impacts and trail widening [32]. Another Australian study reported less severe damage [22].

Spectator crowds may cause additional impacts (e.g. off-track vegetation trampling). A German study of a competitive mountain bike racing event showed soil compaction that resulted from bikes was less, although deeper, compared to that from the spectators, with recovery taking approximately 19 months [48].

Owing to the risk of such potential impacts and a relative lack of empirical, comparable data [10], even non-competitive, cross-country recreational mountain biking remains restricted or banned in many protected areas with a conservation mandate. Examples include parts of the Cairngorm Mountains (Scotland) [50] and wilderness areas within the Greater Blue Mountains World Heritage Area (Australia) [51]. But, lobbying pressure from bikers for greater access to such areas is growing. Management agencies need to provide empirical evidence of environmental impacts when making and/or justifying their decisions of whether or not to permit mountain biking (e.g. see [29]).

Studies across several countries have shown that mountain bike riders' preferred settings are large, scenic, natural areas on single, unsealed trails with a variety of features that include steep slopes, short and long curves, jumps, rocks and logs (e.g. [12,32]). Historically, protected areas with at least some element of a conservation mandate (e.g. national parks, nature reserves) have provided settings for the niche/specialised activities of adventure recreation. Social conflicts and/or environmental impacts in such areas resulting from activities such as mountain biking have usually been handled by land managers, first by establishing standards for the activity and then developing regulations [7]. Planning models and management frameworks, such as the 'Recreational Opportunity Spectrum' and 'Limits of Acceptable Change' [52] and 'IMBA Rules of the Trail' [21] have been developed to support such decisions. All depend on agreement among stakeholders on what constitutes acceptable use of public natural areas. If the majority of participants' motivations for using such areas are consumptive, management may find it difficult to apply such tools to mountain biking, especially in its more extreme derivatives. Issues may be exacerbated when visitors and managers perceive impacts differently [1,53].

Recreationists' advocacy power is also increasing. Formal (e.g. sports associations, clubs, commercial media organisations) and informal (e.g. weblogs, online forums) groups are becoming more influential [46]. Recreationists' lobbying power may also be supported by the associated tourism and retailing industries who have commercial interests. Managers of areas with a conservation mandate may also be confronted with threats of appeals and litigation against their efforts to restrict what they perceive to be inappropriate recreational activities. Potential for litigation may grow because of the perceived risk of injury [54]. The reach of the internet enhances such stakeholders' lobbying power [55]. For example, in the 1990s in at least three UK national parks there were campaigns by the mountain biking lobby that resulted in changes in the decisions of land managers. Mountain biking in Dartmoor was initially a criminal offence, while Exmoor considered it an 'unsuitable activity', and Snowdonia attempted to ban mountain bikers from its bridleways. Mountain biking has since become an accepted activity in these parks, although opposition from other users continues [56].

Appropriateness of public natural areas

In several countries growth in adventure recreation activities, such as mountain biking has caused a shift in their provision from public natural areas with a conservation mandate to others with a production primacy mandate and/or private lands. The most important examples are forestry lands. In common with national parks, forests offer large areas of natural landscapes, often with rugged, challenging terrain and scenic beauty, but their management is less focused on conservation than that of national parks. In the USA, the Department of Agriculture manages 77 million ha of public forests and grasslands for the USA Forest Service [57]. In the UK, the Forestry Commission is the country's largest land manager with 800,000 ha of woods and forests [58]. In Australia, management of the estimated 13 million ha of public forests is under the jurisdiction of the various state and territory governments [59–64].

Although their political and legal structures may differ, the public forests of all three countries are managed as a harvestable resource for the supply of industries such as construction and furniture timbers. Some in the public may have perceived these areas as a primary recreation resource, but generally the land owners have not perceived the public's commercial potential as recreationists. More recently, however, such potential has been recognised and even become necessary. For example in Tasmania (Australia) and Canada, public pressure for the protection of old-growth forests for wildlife and/or carbon sequestration is limiting logging (e.g. [65–67]).

Although logging companies gain high returns from timber harvesting, the economics depend on low cost, high volume production (e.g. wood chipping) and consequently clear-felling; an unsustainable practice [11]. This is raising pressure for additional, complementary income streams from existing forestry estates. If such issues are emerging in countries of large geographic size and low population such as Australia and Canada, they are already acute in smaller, more densely populated countries such as the UK where recreational use of forests is now acknowledged as the primary socio-economic value of the public forest estates [68]. Mountain biking is an economically beneficial form of such forest-based recreation.

Forestry-based mountain biking – the UK experience

The first purpose-built, forest-based mountain bike venue in the UK was at Coed-y-Brenin (North Wales). Opened in the mid-1990s, its success sparked similar developments elsewhere in the country. There are 40 purpose-built mountain biking/forest cycling Centres/Bases currently operated by the Forestry Commission of Great Britain; 15 in Scotland [69], 13 in Wales [70,71] and 12 in England [72] with five more planned. Throughout the UK these venues, together with other cycle ways, provide more than 2600 km of tracks on national forest estate lands [17]. These include 'Centres' dedicated to single site mountain biking locations with a visitor centre and support facilities (e.g. café, bike repair shop, showers and toilets, trail guides), offering multiple-way, marked trails of varying difficulty. Alternatively, 'Bases' host several way-marked or mapped trails, together with independently operated support facilities (e.g. accommodation, restaurants/café, bike sale and/or repair shop) [71]. Located in sparsely populated, poorer rural areas, their development also offers substantial economic benefits through employment [17,23].

Although use of the trails is free, supporting facilities are provided on a commercial basis. These initiatives are public – private sector partnerships, led by the respective regional forestry commissions and comprising local governments, national and regional tourism bodies, together with local private enterprises. Although all centres have proved successful, those in Scotland especially have prospered. For example, the Nevis Range and Leanachan Forest venues (Fort William, Scotland) hosted the annual World Cup Mountain Bike Series during 2002–2005 and again in 2010. In 2007, they also hosted the Mountain Bike World Championships with international competition for four mountain bike disciplines: Downhill, Cross-Country, Trials and 4-Cross. The Scottish town of Dumfries hosted the 2010 World Mountain Bike Conference, and the 2014 Commonwealth Games will be held in Glasgow [17]. As cross-country mountain biking is a Games event, this will bring more attention to the sport, and the Scottish venues in particular.

The largest of the UK's mountain biking venues is the 7stanes project in Southern Scotland [69]. Opened in 2001, this multi-agency, seven-centre network is a world-class mountain biking venue that attracts domestic and international visitors. There are nearly 600 km of single track trails of varying levels from 'easy' to 'severe'. The 'difficult' trails are most popular. There are also Action Trail Areas for freestyle enthusiasts, and additional non-way marked and ungraded forest trails [17,23]. Forty-nine percent of visitors are 'intermediate' riders, 30% 'advanced' and 8% 'beginners' [23].

Highly experienced mountain bike riders were targeted as 'early adopters' and the focus was on product (e.g. trail building, infrastructure development). The strategy is to widen the user base, attract new users into the sport and make it more accessible socially, especially to females, families, schools and older visitors. This equates to the development of a true mass market tourism/recreation product.

There have been substantial economic benefits for a mainly rural region that has traditionally suffered high unemployment [17]. In 2007, 7stanes attracted an estimated 395,000 visitors (increased from 172,000 in 2004), making it one of the 20 most popular Scottish tourist attractions. Some 43% of visitors came from within Scotland, 32% from elsewhere in the UK and 5% from overseas. For 78% of visitors 7stanes was their primary reason for visiting the region and more than one-third stayed at least overnight (up from 25% in 2004). The project's net economic benefits are estimated to be £9.18 million (USA \$14.53) in tourism expenditure, creation of 212 full time equivalent jobs and £3.72 million (USA \$5.89) gross value added to the regional economy [23]. Other forest-based mountain biking centres in the UK have produced comparable economic benefits to their respective regions and local communities [17].

The 'trail' ahead: future research and management implications

Mountain biking is especially popular in affluent, economically developed countries where governments are keen to promote healthy exercise and whose citizens are expected to enjoy increasing leisure time in the coming decades [73]. Mountain biking will probably continue to produce new derivatives undertaken for tourism/recreation and as competitive, formalised sports; for example, the popularity of night mountain biking in some areas of the UK.

With a widening diversity of participants seeking different experiences, there will be more social and/or environmental management challenges for land managers. The main challenge is to innovate and not to react negatively. The UK Forestry Commission case

shows that tourism/recreation demand and commercial natural resource production supply have successfully collaborated to produce a 'win-win' solution for a range of stakeholders.

Commercially harvested forests are potentially an appropriate or complementary resource to national parks for mountain biking as they (1) provide the large spaces in natural settings that are required; (2) are less biologically sensitive to anthropogenic impacts; (3) may offer substantial economic benefits to local rural communities; and (4) may offer substantial economic benefits to the owners of the lands.

To assist decision-making by the various public/private stakeholders in the multi-agency partnerships, research is needed to provide a better understanding of (1) the environmental impacts emanating from mountain biking activities across different ecosystems; and (2) the demographics and psychographics of the mountain bikers themselves. With such information, and with models of environmentally sustainable operations available, potential conflict over access to and/or inappropriate use of public lands of importance for conservation could be reduced. Land managers could then better manage biodiversity by offering options elsewhere and thus clear the trail for mountain biking.

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