7 Mountain Biking

Chapter Summary
This chapter first defines mountain biking (MTB), its history and development, and the range of different bikes used. It then examines participation numbers before considering the history, designs, and disciplines with MTB. The final part of the chapter focuses on specific environmental impacts: damage to soil, vegetation, and water and the impacts on wildlife. The final section considers the management of these activities such as trail design and the development of the forest-based MTB centres in the UK and gives some examples of education initiatives such as the International Mountain Biking Association Rules of the Trail which have been used in management attempts.

7.1 Definitions

7.1.1 Mountain Biking (MTB)

The mountain bike was developed in Marin County, California, in the mid-1970s. The conventional bike was strengthened and made more flexible, quickly evolving into the form seen today, with front and rear suspensions available (Fig. 7.1). The first mountain bike was introduced into the UK in 1983, and though no specific records of sales are kept, the overall purchase of cycles is running at a very high level.

Mountain bikes are designed for off-road use, although of course they can be used on paved road, but their heavier weights and more upright sitting position means that they are generally not as fast as modern-day road bikes. Mountain bikes share similarities with other bikes but incorporate features designed to enhance durability and performance in rough terrain. These typically include front or full (front and rear) suspension, large knobby tyres, more durable wheels and spokes, more powerful brakes (usually disc brakes), and lower gear ratios for climbing steep hills. Mountain bikes are typically ridden on mountain trails, which may often be purpose-built single track, fire roads, and other unpaved surfaces. This type of terrain usually has tree roots, loose dirt, rocky surfaces, and steep grades. Many purpose-built trails will also have additional features such as log piles, log rides, rock gardens, gap jumps, and wall rides. Mountain bikes are built to handle these types of terrain and features.

Since the development of the sport in the 1970s, many new subtypes of MTB have developed, such as cross-country (XC), all-day endurance, freeride, downhill, and a variety of track and slalom types. Each of these requires different designs for optimal performance. MTB development has led to an increase in suspension travel, now often up to 8 inches (200 mm) and gearing up to 27 speeds, to facilitate both climbing and

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Fig. 7.1 A full-suspension mountain bike. Photo by Tim Stott

rapid descents. Advancements in gearing have also led to a "1x" (pronounced "one-by") trend, simplifying the gearing to one chain ring in the front and a cassette at the rear, typically with 9–12 sprockets. The expression "all terrain bike" and the acronym "ATB" are used as synonyms for "mountain bike."

7.1.2 Fatbikes

A fatbike (also called fat bike or fat-tyre bike) is an off-road bicycle with oversized tyres, typically 3.8 inches (97 mm) or larger and rims 2.6 inches (66 mm) or wider, designed for low ground pressure to allow riding on soft unstable terrain, such as snow, sand, bogs, and mud. Fatbikes are built around frames with wide forks and stays to accommodate the wide rims required to fit these tyres. The wide tyres can be used with inflation pressures as low as 340 hPa (5 psi) to allow for a smooth ride over rough obstacles. A rating of 550–690 hPa (8–10 psi) is suitable for the majority of riders.

7.1.3 BMX Bikes

A BMX bike is an off-road sport bicycle used for racing and stunt riding. BMX means bicycle motocross. Although the term BMX originally meant a bicycle intended for BMX racing, the term "BMX bike" is now used to encompass race bikes, as well as those used for the dirt, vert, park, street, flatland, and BMX freestyle disciplines of BMX.

7.2 Participation Numbers

In the USA, during the 2016 calendar year, a total of 24,134 online interviews were carried out with a nationwide sample of individuals and households from the US Online Panel of over one million people operated by Synovate/IPSOS (Outdoor Foundation 2017). A total of 11,453 individual and 12,681 household surveys were completed. The total panel is maintained to be representative of the US population for people ages six and older. Oversampling of ethnic groups took place to boost response from typically under-responding groups. The 2016 participation survey sample size of 24,134 completed interviews provides a high degree of statistical accuracy.

As can be seen in rows 3–5 of Table 7.1, BMX and mountain (non-paved surface) commanded participation numbers of 1,655,000 and 6,751,000, respectively, in 2006, and these figures rose to 3,104,000 and 8,615,000 in 2016, three-year increases of 43.2% for BMX riding and 0.9% for MTB. These numbers are still a relatively small proportion of the participation numbers for road/paved bicycling which were 38,475,000 in 2006 and 38,365,000 in 2016 with a three-year change of −6.2%. So, the participation in BMX seems to be the biggest growth area, although total numbers are still lower than for MTB.

Although not as up to date at the Outdoor Foundation survey, Cordell's (2012) report lumped together road biking, MTB, and BMX and showed that bicycle participation in outdoor activities in the USA exceeded hiking and was on a par with jogging/trail running and car/back yard/RV camping (Fig. 7.2).

Additionally, in Cordell's (2012) report (Table 7.2), he showed that the number of people in the USA (1999–2001) bicycling on mountain/hybrid bikes was 44 million (18% of the total number aged >16 participating in outdoor activities), although this had declined to 42.7 million by the time of his 2005–2009 survey.

Table 7.1 Outdoor participation by activity (ages 6+) in the USA, 2006–2016 (The Outdoor Foundation 2017, p. 8)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	3-year change (%)
Adventure racing	725	698	920	1089	1339	1065	2170	2213	2368	2864	2999	35.5
Backpacking overnight >¼ mile from vehicle/home	7076	6637	7867	7647	8349	7095	8771	9069	10,101	10,100	10,151	11.9
Bicycling (BMX)	1655	1887	1904	1811	2369	1547	2175	2168	2350	2690	3104	43.2
Bicycling (mountain/non-paved surface)	**6751**	**6892**	**7592**	**7142**	**7161**	**6816**	**7714**	**8542**	**8044**	**8316**	**8615**	**0.9**
Bicycling (roads/paved surface)	38,457	38,940	38,114	40,140	39,320	40,349	39,232	40,888	39,725	38,280	38,365	−6.2
Birdwatching (more and ¼ mile from home/vehicle)	11,070	13,476	14,399	13,294	13,339	12,794	14,275	14,152	13,179	13,093	11,589	−18.1
Boardsailing/windsurfing	938	1118	1307	1128	1617	1151	1593	1324	1562	1766	1737	31.2
Camping (RV)	16,946	16,168	16,517	17,436	15,865	16,698	15,108	14,556	14,663	14,699	15,855	8.9
Camping (with ¼ mile of home/vehicle)	35,618	31,375	33,686	34,338	30,996	32,925	29,982	29,269	28,660	27,742	26,467	−9.6
Canoeing	9154	9797	9935	10,058	10,553	9787	9839	10,153	10,044	10,236	10,046	−1.1
Climbing (sports/indoor/boulder)	4728	4514	4769	4313	4770	4119	4592	4745	4536	4684	4905	3.4
Climbing (traditional/ice/mountaineering)	1586	2062	2288	1835	2198	1609	2189	2319	2457	2571	2790	20.3
Fishing (fly)	6071	5756	5941	5568	5478	5683	6012	5878	5842	6089	6456	9.8
Fishing (freshwater/other)	43,100	43,859	40,331	40,961	38,860	38,868	39,135	37,796	37,821	37,682	38,121	0.9
Fishing (saltwater)	12,466	14,437	13,804	12,303	11,809	11,983	12,017	11,790	11,817	11,975	12,266	4.0
Hiking (day)	29,863	29,965	32,511	32,572	32,496	34,491	34,545	34,378	36,222	37,232	42,128	22.5
Hunting (bow)	3875	3818	3722	4226	3908	4633	4075	4079	4411	4564	4427	8.5
Hunting (handgun)	2525	2595	2873	2276	2709	2671	3553	3198	3091	3400	3512	9.8
Hunting (rifle)	11,242	10,635	10,344	11,114	10,150	10,807	10,164	9792	10,081	10,778	10,797	10.3
Hunting (shotgun)	8987	8545	8731	8490	8062	8678	8174	7894	8220	8438	8271	4.8
Kayak fishing	n/a	n/a	n/a	n/a	1044	1201	1409	1798	2074	2265	2371	31.8
Kayaking (recreational)	4134	5070	6240	6212	6465	8229	8144	8716	8855	9499	10,017	14.9
Kayaking (sea/touring)	1136	1485	1780	1771	2144	2029	2446	2694	2912	3079	3124	16.0
Kayaking (white water)	828	1207	1242	1369	1842	1546	1878	2146	2351	2518	2552	18.9

(continued)

Table 7.1 (continued)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	3-year change (%)
Rafting	3609	3786	4226	4342	3869	3725	3958	3915	3924	4099	4095	−10.6
Running/jogging	38,559	41,064	41,130	43,892	49,408	50,713	52,187	54,188	51,127	48,496	47,384	−12.6
Sailing	3390	3786	4226	4342	3869	3725	3958	3915	3924	4099	4095	4.6
Scuba diving	2965	2965	3216	2723	3153	2579	2982	3174	3145	3274	3111	−2.0
Skateboarding	10,130	8429	7807	7352	6808	5827	6627	6350	6582	6436	6442	1.5
Skiing (alpine/downhill)	n/a	10,362	10,346	10,919	11,504	10,201	8243	8044	8649	9378	9267	12.4
Skiing (cross-country)	n/a	3530	3848	4157	4530	3641	3307	3377	3820	4146	4640	40.3
Skiing (freestyle)	n/a	2817	2711	2950	3647	4318	5357	4007	4564	4465	4640	2.7
Snorkelling	8395	9294	10,296	9358	9305	9318	8011	8700	8752	8874	8717	0.2
Snowboarding	n/a	6841	7159	7421	8196	7579	7351	6418	6785	7676	7602	3.4
Snowshoeing	n/a	2400	2922	3431	3823	4111	4029	3012	3501	3885	3533	−12.3
Stand up paddling	n/a	n/a	n/a	n/a	1050	1242	1542	1993	2751	3020	3220	61.6
Surfing	2170	2206	2607	2403	2767	2195	2895	2658	2721	2701	2793	3.0
Telemarking (downhill)	n/a	1173	1435	1482	1821	2099	2766	1732	2188	2569	2848	3.0
Trail running	4558	4216	4857	4833	5136	5610	6003	6792	7531	8139	8582	26.4

Note: All participation numbers are in thousands (000)

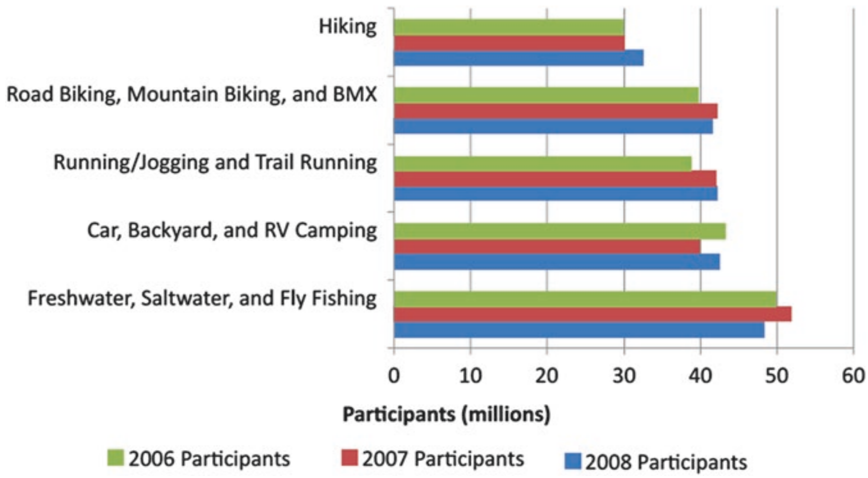

Fig. 7.2 Participation in gateway outdoor activities. Source: Cordell (2012, p. 27)

Table 7.2 Trends in number of people ages 16 and older participating in recreation activities in the USA, 1999–2001 and 2005–2009 for activities with between 25 and 49 million participants from 2005 through 2009 (Source: Cordell 2012, p. 37)

	Total participants (*millions*)			Percent participating	Percent change
	1994–1995	1999–2001	2005–2009	2005–2009	1999–2001 to 2005–2009
Visit archaeological sites	36.1	44.0	48.8	20.8	11.1
Off-highway vehicle driving	35.9	36.0	48.4	20.6	34.5
Boat tours or excursions	–	40.8	46.1	19.6	13.1
Bicycling on mountain/hybrid bike	**–**	**44.0**	**42.7**	**18.1**	**–3.0**
Primitive camping	31.4	33.1	34.2	14.5	3.2
Sledding	27.7	30.8	32.0	13.6	3.9
Coldwater fishing	25.1	28.4	30.9	13.1	8.7
Saltwater fishing	22.9	21.4	25.1	10.7	17.2

Missing data are denoted with "–" and indicate that participation data for that activity were not collected during that time period. Percent change was calculated before rounding

Source: USDA Forest Service (1995) (n = 17,217), USDA Forest Service (2001) (n = 52,607), and USDA Forest Service (2009) (n = 30,398)

Note: The numbers in this table are *annual* participant estimates on data collected during the three time periods

1994–1995 participants based on 201.3 million people ages 16+ (Woods & Poole Economics, Inc. 2007)

1999–2001 participants based on 214.0 million people ages 16+ (U.S. Department of Commerce 2000)

2005–2009 participants based on 235.3 million people ages 16+ (U.S. Department of Commerce 2008)

Unfortunately, as far as we are aware, there is no such equivalent comprehensive survey of participation numbers in Europe or any other part of the world to date, although Sport England's Active People Survey (Table 7.3) offers some indicative figures for cycling and recreational in general and for BMX, cyclo-cross, and MTB in England for 2012–2013. It would seem that there are in the region of 3.6 million participants over the age of 14 taking part in cycling (8.1% of the adult population) with around 2.1 million classed as recreational cycling. However, it is not clear whether these numbers are in addition to the general cycling figures or part of them. Some 736,900 participated in MTB, 27,300 in cyclo-cross, and 54,000 in BMX. So these figures reflect the trends

Table 7.3 Average monthly participation[a] in sport and recreation in England, October 2012–2013

Activity	Number of people (14+) participating monthly	Percentage of the adult population (14+)
Outdoor recreation group	25,703,100	59.3
Outdoor recreation group (excluding walking)	7,707,500	17.8
Coarse fishing	632,800	1.4
Game fishing	155,800	0.4
Sea fishing	245,900	0.6
Running	2,791,500	6.3
Canoeing	133,300	0.3
Cycling	3,524,400	8.1
BMX	54,000	0.1
Cyclo-cross	27,300	0.1
Mountain biking	736,900	1.7
Recreational cycling	2,159,800	5.0
Pony trekking	35,300	0.1
Other horse riding	301,700	0.7
Outdoor climbing	191,200	0.4
Orienteering	11,800	0.0
Water-based rowing	47,500	0.1
Windsurfing	19,400	0.0
Cruising sailing	47,600	0.1
Alpine skiing	95,900	0.2
Freestyle skiing	22,300	0.1
Nordic skiing	17,400	0.0
Snowboarding	29,100	0.1
Outdoor swimming	826,700	1.9
Recreational walking	23,313,500	53.8

Source: Sport England, 2014, Active People Survey
[a]At least one session of any duration in the last 28 days

seen in the US data provided in the Outdoor Foundation (2017) study (Table 7.1).

Other nations in which MTB 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 (Koepke 2005). In Australia, the number of cyclists grew by 15.3% between 2001 and 2004 (Faulks et al. 2008), and of the 753,843 bikes sold in 2004, 70% were mountain bikes (Bradshaw 2006). Although the percentage of such bikes used for off-road riding and their frequency of use are unknown, such data suggest that MTB is growing worldwide (Hardiman and Burgin 2013). International Mountain Biking Association (IMBA) is now represented in 17 countries including the USA, Australia, Canada, Italy, Mexico, Spain, Netherlands, and UK, and their code of conduct is considered universal (International Mountain Biking Association 2013).

7.3 History, Designs, and Disciplines with MTB

7.3.1 History

The original mountain bikes were modified heavy cruiser bicycles used for freewheeling down mountain trails. The sport became popular in the 1970s in Northern California, USA, with riders using older single-speed balloon-tyre bikes to ride down rugged hillsides. By the late 1970s and early 1980s, road bike companies began to manufacture mountain bikes using high-tech lightweight materials, such as M4 aluminium. The first mass production mountain bike was the Specialized Stumpjumper, produced in 1981. Throughout the 1990s and 2000s, MTB moved from a little-known sport to a mainstream activity complete with an international racing circuit and a world championship, in addition to various freeride competitions, such as the FMB World Tour and the Red Bull Rampage.

7.3.2 Designs

Mountain bikes can be divided into three broad categories based on suspension configuration:

- *Rigid*: a bike with neither front nor rear suspension
- *Hardtail*: a bike equipped with a suspension fork (front wheel) but otherwise a rigid frame
- *Full suspension (or dual suspension)*: a bike equipped with both front and rear suspensions. The front suspension is usually a telescopic fork similar to that of a motorcycle, and

the rear by a mechanical linkage with components for absorbing shock.

There are several different styles of MTB, usually defined by the terrain, and therefore bikes employed. Styles of mountain bike riding and mountain bikes have evolved rapidly in recent years leading to terms such as freeride and "Trail bike" being used to categorise mountain bikes.

7.3.3 MTB Disciplines

Cross-country (XC) mountain bikes are designed primarily around the discipline of cross-country racing, placing emphasis on climbing speed and endurance and therefore demanding lightweight, efficient bikes (Fig. 7.4B). In the 1980s and early 1990s, XC mountain bikes typically consisted of a lightweight steel hardtail frame with rigid forks. Throughout the 1990s, XC bikes evolved to incorporate lightweight aluminium frames and short-travel (65–110 mm) front suspension forks. Recently full-suspension designs have become more popular among racers and enthusiasts alike, and the use of advanced carbon fibre composites has allowed bike designers to produce full-suspension designs which weigh under 10 kg. In recent years 29 "wheels have largely replaced the original standard of 26"; the US men's and women's marathon cross-country races were won on 29ers in 2009 and 2010. The geometry of cross-country bikes favours climbing ability and fast responses over descending and stability, and although intended for off-road use, XC bikes are not designed for use on steep or particularly rough terrain. Put in terms of rider emphasis, XC bikes are designed for approximately 80% uphill or flat riding and 20% downhill.

Trail bikes are a development of XC bikes that are generally used by recreational mountain bikers either at purpose-built "trail centres" or on natural off-road trails. They usually have around 120–140 mm (5 inches) of travel, weigh 11–15 kg (24–33 lb), and have geometries situated somewhere between full XC and All-Mountain bikes. With less of an emphasis on weight, Trail bikes are typically built to handle rougher terrain than dedicated XC bikes, and they provide greater stability while descending. Trail bikes are designed for approximately 60–70% uphill and 30–40% downhill riding.

Enduro/All-Mountain (AM) bikes bridge the gap between XC and freeride bikes which typically weigh between 13 and 16 kg (29 to 35 lb). These bikes tend to feature greater suspension travel, frequently as much as 150 mm (6 or 7 inches) of front and rear travel, often adjustable on newer mid- and high-end bikes. Designed to be able to climb and descend well, these bikes are intended to be taken on all-day rides involving both steep climbs and steep descents, hence the term "all-mountain." In terms of aggressiveness, these bikes are intended for anywhere from 50–70% downhill riding to 30–50% uphill riding, bridging the gap between trail and downhill bikes. In recent years, there has been somewhat a split between Enduro and All-Mountain bikes, with the former placing more emphasis on descent due to the increased emphasis on timed downhill runs in enduro racing when compared to more typical All-Mountain riding.

Downhill (DH) bikes typically have eight or more inches (200 mm) of suspension travel and extremely low, slack geometry intended to set the rider in a comfortable position when descending steep trails at high speed (Fig. 7.4C). Due to their often high gear ratios, soft suspension, and aggressive geometry, downhill bikes are ideal only for riding down dedicated trails or race courses. Some mechanical uplift is usually employed which may be using a ski lift or telepherique outside of the ski season, or an agricultural tractor or other vehicle pulls a trailer back up the hill with the bikes and riders on board. Occasionally riders may push or carry their downhill bike uphill as they are too heavy to ride. Downhill frames are often intended for racing and as such are required to be both extremely durable and lightweight. Bicycle designers often make use of similar materials in the construction of downhill and XC frames and components (e.g. carbon fibre), despite their vastly different purposes, as the ultimate goal of a high strength to weight ratio is the same. In recent years, more advanced frame and component designs have produced high-end downhill bikes with similar weights to average Trail and All-Mountain bikes, with an increasing expectation that complete downhill bikes remain below 18 kg (40 lb).

Freeride (FR) mountain bikes are similar to downhill bikes, with less emphasis on weight and more on strength. Freeride bikes have ample suspension and typically have at least 180 mm (7 inches) of travel. Freeride bikes are intended for trail features with large air time, such as jumps and drops, and as such are designed to handle heavy impacts, whether from landings or crashes. Freeride frames and parts are rarely made from carbon fibre due to strength and durability concerns and are instead usually made from aluminium, sacrificing marginal weight gain for more predictable material response under heavy usage. Certain freeride-specific bikes can be ridden uphill more easily than downhill bikes but are nevertheless still inefficient in pedalling and difficult to manoeuver while angled uphill. Originally, freeride bikes sat between All-Mountain and downhill bikes in geometry, with frame angles steeper than those found in downhill bikes with higher rider positioning, enhancing manoeuvrability on technical or low-speed features commonly found on "North Shore"-style trails. Freeride bikes typically range in weight from 14 to 20 kg (31 to 44 lb). Slopestyle and Dirt Jump bikes are included in this category by some, due to similar purposes, but the distinction in bike design is significant between the three.

Dirt jumping, urban, and street mountain bikes lie somewhere in between a BMX bike and a freeride bike. They are rigid or hardtail bikes, with 76–114 mm (3–4.5 inches) of front suspension and rigid, durable frames with low bottom brackets and short chain stays to improve manoeuvrability. Dirt Jump bikes often overlap in design with Four-Cross bikes, though that discipline has dropped in popularity, with many frames including removable derailleur hangers and/or integrated chain tensioners to allow for single-speed and multi-speed arrangements (Four-Cross bikes mostly use derailleurs, while dirt jumpers usually use single-speed setups). Tyres on these bikes are usually 24 or 26″ diameter, fast-rolling slicks (tyres without tread), or semi-slicks. Dirt jumpers usually have low seat posts and oversized handlebars, to make room for tricks. Most dirt jumpers have an extended rear brake cable installed and have no front brake, which allows the rider to spin the handle bars multiple times without tangling the brake cables.

Slopestyle (SS) bikes are a strange blend of Dirt Jump and freeride bikes, having the geometry similar to dirt jumpers but with approximately 100 mm (4 inches) of suspension travel in both the front and rear forks. These bikes are mostly used by professional slopestyle riders, this specific usage being their origin, and as such are designed for the extremely large jumps and high speeds encountered in competition. The frames are either adapted from existing All-Mountain or freeride designs or designed specifically for the purpose, with durable frame designs and sophisticated suspension linkages to make the most of their minimal suspension travel.

Trials bikes are set up very specifically for the purpose of bike trials. Two varieties of trials bike exist, those with 26" wheels (referred to as "stock") and those with 20" wheels (referred to as "mod"—because historically they were modified BMX bikes). They typically have no suspension at all, though some still make use of some form of it. Competition rules require stock bikes to have multiple gears for competition, but most riders never use their shifters. Competition rules do not require mod bikes to have any gears. Many non-competitive riders run single-speed, choosing a fairly low-speed, high-torque gear. Most modern trials bikes have no seat at all, as the rider spends all of his time out of the saddle, and trials riding is not conducive to the use of the saddle as a control interface as in normal MTB. These bikes are significantly lighter than almost all other mountain bikes, ranging from 7 to 11 kg (15 to 24 lb) which makes manoeuvring the bike much easier.

Single-speed (SS) mountain bikes have one set gear ratio. The gear ratio chosen depends on the terrain being ridden, the strength and skill of the rider, and the size of the bike (a bike with 29" wheels often requires a different gearing than a bike with standard 26" wheels). Often single-speeds are fully rigid, steel-framed bikes.

These are typically ridden by very fit individuals on mild to moderate cross-country terrain.

Mountain cross or Four-Cross (4X) is a type of racing in which four bikers race downhill on a prepared, BMX style track. Four-Cross racing has fallen in popularity recently, with the UCI removing Four-Cross from the World Cup due to excessive erosion and inconvenience caused by the purpose-built race tracks. *Dual slalom (DS)* is similar to Four-Cross, but instead of four competing cyclists during a race, there are only two, racing in parallel lanes. The courses are in general more technical with smaller jumps than Four-Cross courses. Dual slalom races originally took place on grass slopes with gates and minimal jumps but are now held on man-made courses. Dual slalom racers will usually use Slopestyle or Dirt Jump bikes. *Indycross (IX)* is essentially a mountain cross event featuring a wide variety of features run by one competitor per time. *North Shore* bikes are much like freeride bikes in their geometry and downhill bikes in their component makeup. Because North Shore stunts have evolved to not only include simple and complex bridges but also large drops and high-speed descents through a series of stunts, North Shore bikes commonly have as much travel as downhill and freeride bikes, however with much more nimble and manoeuvrable frame designs and often lighter weight.

Circle dirt-track racing is a class of racing in which any kind of bikes are used, most commonly a hardtail mountain bike with front suspension. Many different modifications are made to track racing bikes, such as reducing bike weight, increasing brake power, trying different cambers (so that when the bike leans, the tyre is more level with the track thus creating more grip), and trying different gear ratios.

7.4 Environmental Impact

Infrastructure to support the various forms of MTB such as purpose-built single track trails, uplift facilities for downhill, and bike parks for freeriding/trials is increasing in many countries (Koepke 2005; IMBA 2010). In the USA, locations such as Moab (Utah) and Fruita (Colorado) each offers hundreds of kilometres of single track mountain bike trails in desert ecosystems (MATC 2010). In Canada, alpine resorts such as Whistler Blackcomb offer more than 200 km of trails for MTB, including 34 trails of lift-serviced downhill routes. An indication of how important MTB has become to such resorts is that summer revenue now represents approximately 75% of winter snow recreation revenue (TRC 2005; Whistler Blackcomb n.d.).

Significant economic benefits can be gained from developing and promoting MTB in its various forms. Examples include destination MTB tourism and competitive sporting events, typified by the World Cup Mountain Bike Series, Union Cycliste Internationale Mountain Bike, and Trials Championship. MTB also provides social networking opportunities and supports a substantial industry in both equipment and clothing.

7.4.1 Damage to Soil and Vegetation

The rising popularity of MTB has raised concerns of potential environmental impacts (see Burgin and Hardiman 2012 for review). The IMBA “rules” (see rules 1–3, Table 7.4) include 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) (Pickering et al. 2010). Assessing impacts caused by MTB is difficult since mountain bikers often share trails used by others: for hiking, horse riding, and 4WD driving, so the specific effects of MTB often cannot be readily distinguished. 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 board ways used in freeriding/North Shore are becoming more common, even in protected areas (Fig. 7.3).

On flat terrain under dry conditions, recreational MTB 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

Table 7.4 Official IMBA "Mountain Bike Rules of the Trail" in 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 a 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 horseback riders—ask if uncertain. Running cattle and disturbing wildlife is a serious offence. Leave gates as you find 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: International Mountain Biking Association (2013)

with those of walking and less than those from motorised vehicles or horse riding (Chiu and Kriwoken 2003; Thurston and Reader 2001). Figure 7.4 shows the moderate damage to vegetation can easily be caused by the passage of mountain bikes on a moorland in north-east Wales during wet weather in winter. Mountain bikes crossing watercourses (Fig. 7.4B) and passing through waterlogged flushes in upland areas (Fig. 7.4C, D) can release fine sediment which can result in siltation on stream beds. In severe cases, siltation can affect spawning gravels of fish (like salmon) by blocking the flow of water and oxygen to eggs laid within gravels (Wickett 1954; Sear et al. 2017). 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 (White et al. 2006).

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) (Goeft and Alder 2001). This damage may increase trail incision and/or widening, soil erosion, and water runoff. The impact of MTB on erosion is, however, cumulative and curvilinear (Chiu and Kriwoken 2003). After rapid initial erosion, the rate of change declines, probably because of increasing soil compaction.

MTB is becoming more and more popular as a competitive sport, and impacts from competitive MTB probably occur faster and are more acute than those from recreational biking. There is little research into the question of use intensity (e.g. under competitive racing conditions) and/or duration, but large organised mountain bike/challenge events such as The Brecon Beast (http://

Fig. 7.3 Example of a North Shore board way at Llandegla mountain bike centre, North Wales. Photo by Tim Stott

www.breconbeast.co.uk/) are likely to have large impacts over a short space of time (one weekend). However, such events are only held once per year—the trails used do have time to recover. 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. Newsome et al. (2011) argued that adventure racing which might include downhill competitive MTB events, for example, probably poses higher risk of environmental impacts than recreational biking since the element of competition means that competitors have less time to consider their impact on the environment and take ameliorating action.

Australian studies of racing events have found that soil loss at sharp corners is greater than on straight sections (Hawes 1997). 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 (Goeft and Alder 2001). Spectator crowds may cause additional impacts (e.g. off-track vegetation trampling). A German study which evaluated the impacts from a World Championship MTB race with 870 participants and 80,000 spectators showed soil compaction that resulted from bikes was less, although deeper, compared to that from the spectators, with recovery taking approximately 19 months (Wöhrstein 1998). Research studies have consistently revealed that most impact occurs with initial or low use, with a diminishing increase in impact associated with increasing levels of traffic (Hammit and Cole 1998; Leung and Marion 1996). Furthermore, once trampling occurs, vegetative recovery is a very slow process. Wilson and Seney (1994) examined the relative impact of hikers, horses, motorcycles, and off-road bicycles in terms of water runoff and sediment yield on existing trails in Montana. They found that horses and hikers (hooves and feet) made more sediment available than wheels (motorcycles and off-road bikes) and that the effect was most pronounced on pre-wetted trails. However, the study was limited to tests of only 50 and 100 passes by the four modes of travel.

Fig. 7.4 (A) Damage to moorland vegetation due to the passage of mountain bikes on a moorland in NE Wales in winter. Photo by Tim Stott. (B) Mountain bikes crossing watercourses can release fine sediment which can result in siltation on stream beds. Photo by Ewan Stott. (C) Mountain bikes passing through waterlogged flushes in upland areas can cause compaction, remove binding vegetation, and release fine sediments. Photo by Ewan Stott. (D) Mountain bikes passing through upland moorland flatten vegetation. Photo by Tim Stott

7.4.2 Impacts of Mountain Biking on Wildlife

The impacts of MTB on wildlife are similar to those of hikers and other non-motorised trail users. In comparison to the off-road vehicles and snowmobiles discussed in an earlier chapter, mountain bikes at least do not have the noise of an engine. Nevertheless, riders can make noise which can disturb wildlife within a certain range of the activity. An investigation of the interactions of wildlife and trail users (hikers and mountain bikers) was carried out at Antelope Island State Park in Utah by Taylor and Knight (2003). In their study a hidden observer used an optical rangefinder to record the response of pronghorn antelope, bison, and mule deer to an assistant who hiked or cycled a section of trail. The observer then measured wildlife reactions, including flight response, flight distance, alert distance, distance fled, and distance from trail. Their results showed that 70% of animals located within 100 m of a trail were likely to flee when a trail user passed and that wildlife exhibited statistically similar responses to MTB and hiking. Wildlife reacted more strongly to off-trail recreationists, suggesting that visitors who stay on trails would reduce wildlife disturbance. While Taylor and Knight found no biological justification for managing MTB any differently than hiking, they note that bikers cover more ground in a given time period than hikers and thus can potentially disturb more wildlife per unit time. Interestingly, in their study Taylor and Knight also surveyed 640 hikers, mountain bikers, and horseback riders on the island to assess their perceptions of the effects of recreation on wildlife. Most respondents felt that they could approach animals far closer than the flight distance suggested by the research, and 50% felt that recreational users did not have a negative effect on wildlife.

Gander and Ingold (1997) conducted an experimental study in Switzerland to evaluate the disturbance associated with MTB, hiking, and jogging on high elevation chamois (goat-like mammals found in the European mountains). They assessed alert distance, flight distance, and distance fled and found that approximately 20% of the animals fled from trailside pastures in response to visitor intrusions. There were no statistically significant differences, however, between the behavioural responses of animals and the three different types of user, and the authors concluded that restrictions on MTB above the timberline could not be recommended from the perspective of chamois disturbance only.

Park staff of Banff National Park noted that hikers were far more numerous than mountain bikers on the Moraine Lake Highline Trail but that the number of encounters between cyclists and grizzly bears was disproportionately high. Benn and Herrero (2002) investigated this and confirmed that three of the four human-grizzly bear encounters that occurred along the trail during 1997–1998 involved mountain bikers. Previous research had shown that grizzly bears are more likely to attack when they first become aware of a human presence at distances of less than 50 m. Herrero and Herrero concluded that mountain bikers travel faster, more quietly, and with closer attention to the tread than hikers, all attributes that limit reaction time for bears and bikers and increase the likelihood of sub-50 m encounters. In addition, most of the bear-cyclist encounters took place on a fast section of trail that went through high-quality bear habitat with abundant berries. To reduce such incidents, they recommended education, seasonal closures of the trail to bikes and/or hikers, construction of an alternate trail, and regulations requiring a minimum group size for bikers.

Papouchis et al. (2001) evaluated the behavioural responses of desert bighorn sheep to disturbance by hikers, mountain bikers, and vehicles in low- and high-use areas of the Canyonlands National Park, USA. A total of 1029 bighorn sheep-human interaction observations were made, and the authors reported that sheep fled 61% of the time from hikers, 17% of the time from vehicles, and 6% of the time from mountain bikers. They attributed the stronger reaction to hikers, particularly in the high-use area, to more off-trail hiking and direct approaches to the sheep. The researchers recommended that park officials restrict recreational uses to trails, particularly during the lambing and rut seasons, in order to minimise disturbance.

Spahr (1990) studied flushing distances of bald eagles along the Boise River in Idaho when they were exposed to actual and simulated walkers, joggers, fishermen, bicyclists, and vehicles. The highest frequency of eagle flushing was associated with walkers (46%), followed by fishermen (34%), bicyclists (15%), joggers (13%), and vehicles (6%). However, cyclists caused eagles to flush at the greatest distances (mean = 148 m), followed by vehicles (107 m), walkers (87 m), fishermen (64 m), and joggers (50 m). Eagles were most likely to flush when recreationists approached slowly or stopped to observe them and were less alarmed when bicyclists or vehicles passed quickly at constant speeds.

Similar findings have been reported in other studies, where the difference in flushing frequency between walkers and cyclists/vehicles was attributed either to the shorter time of disturbance or the additional time an eagle has to "decide" to fly (Van der Zande et al. 1984).

7.5 Management and Education

7.5.1 Impacts to Vegetation: Management Implications

Trail managers can either avoid or minimise impacts to vegetation through careful trail design, construction, maintenance, and management of visitor use. Marion and Wimpey (2007) make some recommendations to reduce vegetation impacts:

- Design trails that provide the experience that trail users seek to reduce their desire to venture off-trail.
- Locate trails away from rare plants and animals and from sensitive or critical habitats of other species. Involve resource professionals in designing and approving new trail alignments.
- Keep trails narrow to reduce the total area of intensive tread disturbance, slow trail users, and minimise vegetation and soil impacts.
- Limit vegetation disturbance outside the corridor when constructing trails. Hand construction is least disruptive; mechanised construction with small equipment is less disruptive than full-sized equipment; skilled operators do less damage than those with limited experience.
- Locate trails on sidehills where possible. Constructing a sidehill trail requires greater initial vegetation and soil disturbance, but sloping topography above and below the trail bench will clearly define the tread and concentrate traffic on it. Trails in flatter terrain or along the fall line may involve less initial disturbance but allow excessive future tread widening and off-tread trampling, which favour non-native plants.
- Use construction techniques that save and redistribute topsoil and excavated plants (Marion and Wimpey 2007, p. 2).

Marion and Wimpey (2007) also go on to suggest important considerations for maintaining and managing trails to avoid unnecessary ongoing impacts to vegetation:

- While it is necessary to keep trail corridors free of obstructing vegetation, such work should seek to avoid "daylighting" the trail corridor when possible. Excessive opening of the overstory vegetation allows greater sunlight penetration that permits greater vegetation compositional change and colonisation by non-native plants.
- An active maintenance programme that removes tree falls and maintains a stable and predictable tread also encourages visitors to remain on the intended narrow tread. A variety of maintenance actions can discourage trail widening, such as only cutting a narrow section out of trees that fall across the trail, limiting the width of vegetation trimming, and defining trail borders with logs, rocks, or other objects that won't impede drainage.
- Use education to discourage off-trail travel, which can quickly lead to the establishment of informal visitor-created trails that unnecessarily remove vegetation cover and spread non-native plants. Such routes often degrade rapidly and are abandoned in favour of adjacent new routes, which unnecessarily magnify the extent and severity of trampling damage.
- Educate visitors to be aware of their ability to carry non-native plant seeds on their bikes or clothing, and encourage them to remove seeds by washing mud from bikes, tyres, shoes, and clothing. Preventing the introduction of non-natives is key, as their subsequent removal is difficult and costly.
- Educate visitors about low-impact riding practices, such as those contained in the IMBA-approved *Leave No Trace Skills & Ethics: Mountain Biking* booklet (www.LNT.org).

7.5.2 Impacts to Soils: Management Implications

Soil loss is among the longest lasting forms of trail impact, and minimising erosion and muddiness is the most important objective for achieving a sustainable trail. Soil cannot easily be replaced on trails, and where soil disappears, it leaves ruts that make travel and water drainage more difficult, prompting further impacts, such as trail widening. Research indicates that MTB and hiking are very similar in their impact on soils. Other factors, particularly trail grade, trail/slope alignment angle, soil type/wetness, and trail maintenance, are more influential determinants of tread erosion or wetness.

Marion and Wimpey (2007) proposed several tactics for avoiding the worst soil-related impacts to trails:

- Discourage or prohibit off-trail travel. Informal trails created by off-trail travel frequently have steep grades and fall-line alignments that quickly erode, particularly in the absence of tread maintenance. Exceptions include areas of solid rock or non-vegetated cobble.
- Design trails with sustainable grades, and avoid fall-line alignments (see p. 112 for more).
- When possible, build trails in dry, cohesive soils that easily compact and contain a larger percentage of coarse material or rocks. These soils better resist erosion by wind and water or displacement by feet, hooves, and tyres.
- Minimise tread muddiness by avoiding flat terrain, wet soils, and drainage-bottom locations.
- Use grade reversals to remove water from trail treads. Grade reversals are permanent and sustainable—when designed into a trail's alignment, they remain 100% effective and rarely require maintenance (Marion and Wimpey 2007, p. 4).

Other more temporary strategies will require periodic maintenance to keep them effective:

- While the use of a substantial slope (e.g. 5%) helps remove water from trail surfaces, it is rarely a long-term solution. Surface cupping and berm development will generally occur within a few years after trail construction. If it is not possible to install additional grade reversals, reshape the trail to re-establish a cambered surface periodically, and install wheel-friendly drainage dips or other drainage structures to help water flow off the trail.
- If it is not possible to install proper drainage on a trail, consider re-routing problematic trail sections or possibly hardening the surface.
- In flatter areas, elevate and crown the surface to prevent muddiness, or add a gravel/soil mixture in low spots.

It is always important to understand that visitor use of any type on trails when soils are wet contributes substantially greater soil impact than the same activities when soils are dry. So, another effective measure would be to discourage or prohibit the use of trails that are prone to muddiness during rainy seasons or snowmelt. Generally such use can be redirected to trails that have design or environmental attributes that allow them to better sustain wet-season uses.

7.5.3 Impacts to Water Resources: Management Implications

Marion and Wimpey (2007) state that the same trail design, construction, and maintenance measures that help minimise vegetation and soil impacts also apply to water, although some additional measures are needed to protect water resources:

- Trails should avoid close proximity to water resources. For example, it is better to build a trail on a sidehill along a lower valley wall than to align it through flat terrain along a stream edge, where trail runoff will drain directly into the stream.
- It is best to minimise the number of stream crossings. Where crossings are necessary, scout the stream carefully to select the most resistant location for the crossing. Look for rocky banks and soils that provide durable surfaces.
- Design water crossings so the trail descends into and climbs out of the steam crossing, pre-

venting stream water from flowing down the trail.
- Armour trails at stream crossings with rock, geotextiles, or gravel to prevent erosion.
- Include grade reversals, regularly maintained cambered trail surface, and/or drainage features to divert water off the trail near stream crossings. This prevents large volumes of water and sediment from flowing down the trail into the stream and allows trailside organic litter, vegetation, and soils to slow and filter water.
- On some heavily used trails, a bridge may be needed to provide a sustainable crossing.
- Where permanent or intermittent stream channels cross trails, use wheel-friendly open rock culverts or properly sized buried drainage culverts to allow water to cross properly, without flowing down the trail (Marion and Wimpey 2007, p. 5).

The environmental impacts of MTB and rider preferences in southwest Western Australia were analysed by Goeft and Alder (2001) to determine appropriate trail design and to ensure that this popular nature-based activity has minimal environmental impact while meeting rider requirements. Environmental impacts such as soil erosion and compaction, trail widening, and changes in vegetation cover on a recreational trail and racing track were monitored for 12 months to determine the short- and long-term effects of riding during winter (rainy) and summer (dry) seasons. Rider preferences were determined through a survey of mountain bike riders in the region. The study found that trail erosion, soil compaction, trail widening, and vegetation damage can occur, but they can be avoided or minimised with appropriate trail siting, design, and management.

The study also found that rider preferences for downhills, steep slopes, curves, and jumps along with water stations and trail markings need to be included in the siting and design of the trails. When multiple-use trails are considered, mountain bikers are willing to share the trail with most other users, the exception being with motorised vehicles.

Owing to the risk of potential environmental impacts (ground and wildlife disturbance) and a relative lack of empirical, comparable data (White et al. 2006), even non-competitive, cross-country recreational MTB remains restricted or banned in many protected areas with a conservation mandate. Examples include parts of the Cairngorm Mountains (Scotland) (e.g. Hanley et al. 2002) and wilderness areas within the Greater Blue Mountains World Heritage Area (Australia) (NPWS 2001). However, 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 MTB (e.g. Office of Environment and Heritage 2011).

7.5.4 Managing and Educating Mountain Bikers

Studies carried out in several countries have shown that mountain bike riders' preference is to ride in 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. Koepke 2005; Goeft and Alder 2001). Traditionally, protected areas like national parks and nature reserves, which have a responsibility for conservation, have provided settings for the specialised activities of adventure recreation such as MTB. Guidebooks have, arguably, encouraged mountain bikers into such areas resulting in environmental damage and sometimes social conflicts.

Social conflicts and/or environmental impacts in such areas resulting from activities such as MTB have usually been handled by land managers, first by establishing standards for the activity and then developing regulations (Ewert et al. 2006). Planning models and management frameworks, such as the "Recreational Opportunity Spectrum" and "Limits of Acceptable Change" (Stankey et al. 1985) and the "International Mountain Biking Association Rules of the Trail" (Table 7.4) 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 MTB, especially in its more extreme derivatives. Issues may be exacerbated when visitors and managers perceive impacts differently (Burgin and Hardiman 2012; Martin et al. 1989).

As a recreational group, the lobbying power of mountain bikers is increasing. Formal groups such as sports associations and clubs, as well as informal groups which may operate through online forums, are becoming more influential (Cleggett 2010). Tourism and retailing industries who have commercial interests also add influence.

Managers of areas with a conservation mandate are sometimes confronted with threats of litigation or appeals 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 (Sarre 1989). The internet enhances the lobbying power of such stakeholders (AARA 2010). For example, in the 1990s in at least three UK national parks, there were campaigns by the MTB lobby that resulted in changes in the decisions of land managers. MTB in Dartmoor was initially a criminal offence, while Exmoor considered it an "unsuitable activity," and Snowdonia attempted to ban mountain bikers from its bridleways. MTB has since become an accepted activity in these parks, although opposition from other users continues (Palmer 2006).

7.5.5 Forest-Based Mountain Biking: The UK Experience

The first purpose-built, forest-based mountain bike venue in the UK was opened in the mid-1990s at Coed-y-Brenin (North Wales), and its success sparked similar developments elsewhere in the country (Table 7.5).

Throughout the UK these venues, together with other cycle ways, provide more than 2600 km of tracks on national forest estate lands. These include "centres" dedicated to single site MTB 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 (e.g. Fig. 7.5A). "Bases," on the other hand, host waymarked or mapped trails, together with independently operated support facilities (e.g. accommodation, restaurants/cafés, bike sale, and/or repair shop). Located in sparsely populated, poorer rural areas,

Table 7.5 Mountain biking in England: venues listed on the Forestry Commission website

Whinlatter (NW) Whinlatter Duathlon Whinlatter puts the mountain back into mountain biking. The Altura Trail is already a classic affording stunning views, crazy descents and leg burning climbs. Nearest town: Keswick (Sat Nav: CA12 5TW)
Grizedale (NW) Mountain bikers on The North Face Trail Grizedale. Grizedale plays host to The North Face Trail and is a great base for expeditions along the challenging mountainous routes of the southern Lake District. Nearest town: Clitheroe (Sat Nav: LA22 0QJ)
Gisburn Forest (NW) Mountain bikers on The North Face Trail Grizedale. Start your adventure on the Skills Loop where you can learn how to ride or brush up on your trail feature skills from table tops to berms. Or head straight out on the Bottoms Beck or The 8 bike trails. Nearest town: Ambleside (Sat Nav: BB7 4TS)
Delamere (NW) Cyclist on a forest trail. Combining miles of XC trails with a great skills area, Delamere's light soils make it an all year round venue. Cheshire's largest woodland area is a stone's throw from the major cities of the North West and an excellent venue for evening rides. Please note that the car parks are locked at 8pm in summer and 5pm in winter. Nearest town: Northwich (Sat Nav: CW8 2JD)

(continued)

Table 7.5 (continued)

Kielder (NE) Cyclists riding the Lonesome Pine mountain bike trail in Kielder Forest. Wilderness mountain biking at its best with epic red grade trails and cross boarder links to the Newcastleton Seven Stanes Centre. The lakeside blue grade trails offer spectacular views. Nearest town: Bellingham (Sat Nav: NE48 1ER)
Hamsterley Forest (NE) Women's mountain bike event, Hamsterley Forest. The North East's hidden gem, combes miles of cross-country routes with the adrenaline fuelled 4X course of Descend Bike Park. A fantastic place for all levels of skill and experience. Nearest town: Bishop Auckland (Sat Nav: DL13 3NL)
Dalby Forest (Yorks) Mountain biker at Darkgate Dyke in Dalby Forest. With miles of expertly sculpted technical single track you'll want to ride all day. Dixon's Hollow Bike Park ticks all the freeride boxes from North Shore to 4X. Home of the 2010 World Cup XC course that provides a challenge for even the most experienced riders. Nearest town: Pickering (Sat Nav: YO18 7LT)
Cannock Chase (W Midlands) Mountain biking at Cannock Chase. Great mountain biking for all ages and experience in the heart of the West Midlands. Barrel along the Follow the Dog Trail, or the brand new Monkey Trail, or drop in at Stile Cop Bike Park. Nearest town: Rugeley (Sat Nav: WS15 2UQ)
Sherwood Pines (E Mids) Cyclist on a single track mountain bike trail. A wide variety of graded trails guarantee that all riders are catered for. to a warp speed ride around the Kitchener Trail. The ever developing bike park and dirt jumps ensure there is plenty of potential for air time. Nearest town: Mansfield (Sat Nav: NG21 9JH)
Thetford Forest (E) England's largest lowland forest boasts literally hundreds of miles of fast flowing single track. Fast and unrelenting trails make for long and challenging rides but also make it accessible for all level of cyclists. Nearest town: Thetford (Sat Nav: IP27 0AF)
Bedgebury (SE) Cyclist riding a freeride North Shore course. Not far from London, Bedgebury is a truly stunning location to ride. From family routes to fast red grade single track, there is something for everyone. Nearest town: Goudhurst (Sat Nav: TN17 2SJ)
Forest of Dean (SW) Downhill cycle trail. Forest of Dean Cannop Cycle Centre is the ideal base to take in the whole of the forest and its myriad of singletrack and trails. The nearby Sallowvallets bike area is home to the Freeminer Trail and some great short downhill runs. Nearest town: Coleford (Sat Nav: GL15 4)
Haldon Forest Park (SW) Cyclists using the skills area at Haldon Forest Park. Just 15 minutes outside of Exeter, Haldon Forest Park caters for hardened freeriders. The new red grade XC trail gives you a great introduction to the network of trails that wind through the forest. Nearest town: Exeter (Sat Nav: EX6 7XR)

Source: https://www.forestry.gov.uk/forestry/INFD-6QHHV3, accessed 22/2/18

their development also offers substantial economic benefits through employment (TRC 2005).

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 and 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

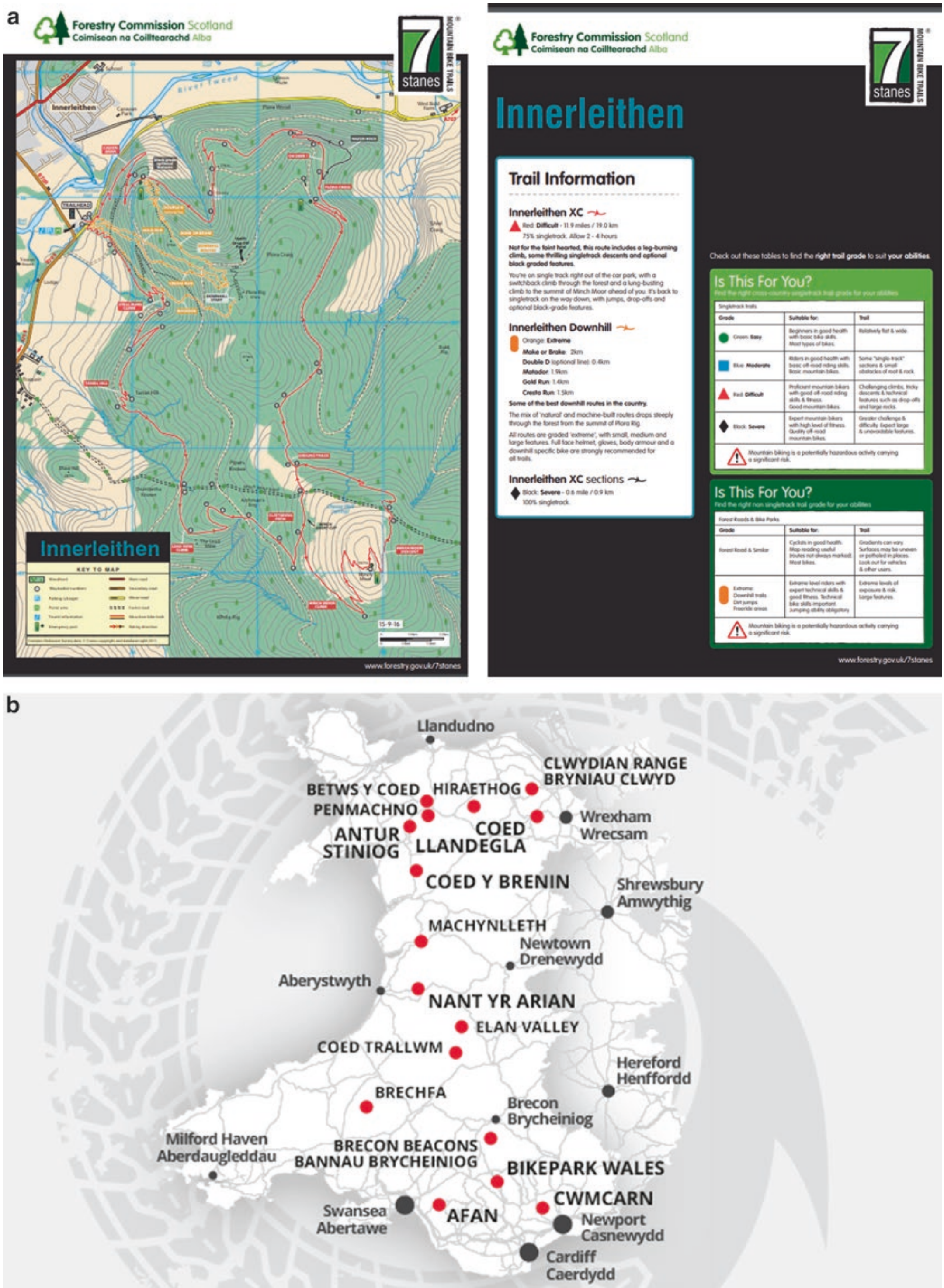

Fig. 7.5 (A) Trail guide for Innerleithen, part of the 7stanes mountain biking suite of trails developed and managed by Forestry Commission Scotland. Source: http://scotland.forestry.gov.uk/images/pdf/rec_pdfs/7stanes-innerleithen.pdf, accessed 22/2/18. (B) Mountain bike centres and bases in Wales which offer a variety of ride experiences. Trails are graded to help riders choose the best to suit their experience. Source: http://www.mbwales.com/, accessed 22/2/18

the 2014 Commonwealth Games was held in Glasgow. The men's and women's cross-country MTB competition was held at the Cathkin Braes Mountain Bike Trails. MTB returned to the Commonwealth Games programme, after last being competed back in 2006. This undoubtedly brought more attention to the sport and the Scottish venues in particular.

The largest of the UK's MTB venues is the 7stanes project in Southern Scotland (Forestry Commission, Scotland, n.d). Opened in 2001, this multi-agency, seven-centre network is a world-class MTB 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-waymarked and ungraded forest trails. 49% of visitors are "intermediate" riders, 30% "advanced," and 8% "beginners" (TRC/EKOS 2007).

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 (TRC 2005). 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, the creation of 212 full-time equivalent jobs, and £3.72 million (USA $5.89) gross value added to the regional economy (TRC/EKOS 2007). Other forest-based MTB centres in the UK have produced comparable economic benefits to their respective regions and local communities.

7.5.6 Future Research and Management Implications for Mountain Biking

MTB is very 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 (Molitor 2000). MTB will probably continue to produce new derivatives undertaken for tourism/recreation and as competitive, formalised sports; for example, night MTB has been popular over the past decade or two 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, seemingly, "win-win" solution for a range of stakeholders.

The forestry history of the UK has helped. The country became depleted of its own timber resources after WWI, and the government set up the Forestry Commission in 1919 to acquire land and plant conifers. This legacy of commercially harvested forests has become an appropriate and complementary resource to national parks for MTB 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 MTB activities across different ecosystems and (2) the demographics and understanding people's motivation for MTB (Taylor 2010). 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 MTB.

Conclusions

1. The mountain bike was developed in Marin County, California, in the mid-1970s since when many new subtypes of MTB have developed, such as cross-country, all-day endurance, freeride, and downhill and a variety of track and slalom types. Fatbikes and BMX are other derivatives.
2. In the USA the Outdoor Foundation's survey (2017) reported that BMX and MTB (non-paved surface) commanded participation numbers of 1,655,000 and 6,751,000, respectively, in 2006, and these figures rose to 3,104,000 and 8,615,000 in 2016, three-year increases of 43.2% for BMX riding and 0.9% for MTB.
3. Cordell (2012) showed that that bicycle participation in outdoor activities in the USA exceeded hiking and was on a par with jogging/trail running and car/back yard/RV camping. He also showed that the number of people in the USA (1999–2001) bicycling on mountain/hybrid bikes was 44 million (18% of the total number aged > 16 participating in outdoor activities), although this had declined to 42.7 million by the time of his 2005–2009 survey.
4. Infrastructure to support the various forms of MTB such as purpose-built single track trails, uplift facilities for downhill, and bike parks for freeriding/trials is increasing in many countries. In the UK there are now over 40 purpose-built MTB/forest cycling centres/bases currently operated by the Forestry Commission of Great Britain. An indication of how important MTB has become to some ski resorts is that summer revenue now represents approximately 75% of winter snow recreation revenue.
5. Environmental damage caused by MTB includes damage to vegetation, soils, and water resources and disturbance to wildlife.
6. Huge progress in managing the impact has been made in the half century since the first mountain bike was developed. Numerous purpose-built centres and bases have specially designed and graded trails for different levels of ability. The IMBA has been educating mountain bikers by commissioning the publication books on managing MTB and its "Mountain Bike Rules of the Trail" which the IMBA considers that "every mountain biker should know and live by…."

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