Population futures and Dartmoor National Park

Implications of development around the outskirts of Dartmoor for recreational use and management of access

EXTENDED SUMMARY
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Report to Dartmoor National Park Authority

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This is an extended summary of the report titled "Population futures and Dartmoor National Park – Implications of developments around the outskirts of Dartmoor for recreational use and management of access". To access information from the full report, please contact the Dartmoor National Park Authority.

A short executive summary can be found at the end of this summary report.

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1 INTRODUCTION

Dartmoor National Park is enjoyed by large numbers of visitors. Significant new housing developments and population growth in the districts around Dartmoor will inevitably result in increases in the number of visitors to the National Park. In order to ensure both high quality recreational experiences and successful environmental protection, there is a need to better understand how new housing developments will impact Dartmoor. In response to that challenge, the Dartmoor National Park Authority (DNPA) outlined the following key questions for which answers were needed:

- Where do visitors currently come from?
- How will housing levels change in the areas around the National Park?
- How may visitor numbers, visitor distribution and types of access change?
- What are the impacts from National Park access and how important are those impacts?
- What needs to be done in terms of mitigation or changes to access management to provide for the changes forecast?

This report, compiled by staff of the SWEEP partnership (www.sweep.ac.uk) at the University of Exeter, sets out to provide answers to those questions.

In achieving that goal the research team have drawn on numerous information sources bringing together secondary data, modelling capacity and drawing on expert inputs in order to present a comprehensive assessment of the impacts on Dartmoor of future population increases.

2 POPULATION FUTURES

Using Office of National Statistics (ONS) population projections augmented by details of proposed property developments described in Local Plans, we construct spatial projections of population change in order to be able to assess the future impacts of recreation on Dartmoor National Park. Due to their connectivity to Dartmoor National Park, our analysis focuses primarily on eight local government areas that define Dartmoor's hinterland, referred to as Local Authority Districts or LADs. These are: West Devon, Teignbridge, South Hams, Exeter, Plymouth, Torbay, Mid-Devon and East Devon.

ONS population projections show that over the 25 years from 2014 to 2039, the overall population in the region is projected to increase by 13% from around 1 million people in mid-2014 to 1.1 million in mid-2039, with differences in population growth between the different LADs. The information on ONS population predictions is then brought together with the details from local plans to provide a spatialized prediction on local population growth. Figure 1 summarises the overall change, mapping out the predicted population changes between 2014 and 2039 in the eight LADs of the Dartmoor hinterland. For full details and methodology, please refer to the full report.

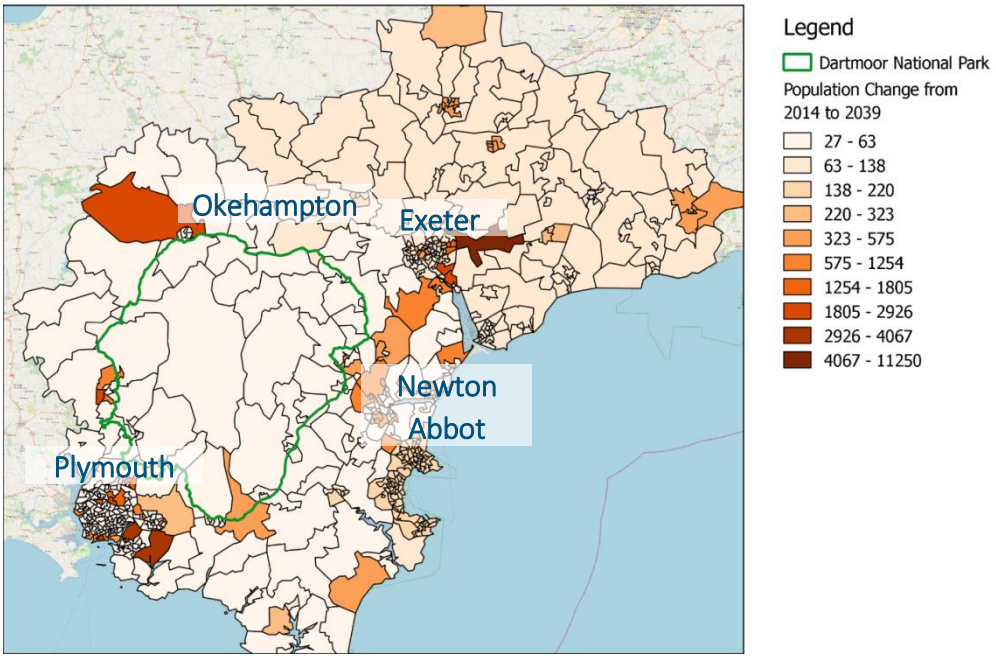

Figure 1: Projected population increases from 2014 to 2039 by LSOA

3 RECREATION FUTURES

3.1 THE ORVAL MODEL

Understanding the likely impacts of the future population changes described in Section 2 requires making forecasts about footfall. In this project our approach to forecasting is to use models based on empirical data describing currently observed behaviour, and use that to predict how future populations might be expected to behave. The core modelling tool used in our analysis is the Outdoor Recreation Valuation (ORVal) model, developed by the LEEP Institute in the University of Exeter. The ORVal model is a statistical recreation demand model that can be used to predict the number of day visits that are made by adult residents of England to different outdoor greenspaces. The model adjusts its predictions according to a number of factors, most particularly the socioeconomic characteristics of people, the day of the week, the month of the year, the attributes of a greenspace and the availability and qualities of alternative greenspaces.

In this project we use the ORVal model to predict visits to Dartmoor. The model allows us to disaggregate those predictions in a number of ways. In particular, we can disaggregate them by home location in order to examine the contribution to visits made by residents of the eight LADs in the Dartmoor hinterland. We can make predictions as to how many of those trips are made by car as opposed to on foot. Moreover, we can disaggregate trips by the locations on Dartmoor at which visitors begin their recreational activity in order to understand how recreational activity is distributed across the National Park. For full details on the ORVal model and methodology please refer to the full report or Day and Smith (2018).

Applying the model to the 2014 population estimates allows us to provide estimates of visits to Dartmoor. We calculate an estimate of 7.8 million annual visits to the National Park. The majority of these day visits (92%) come from the 8 neighbouring LADs, the remainder from the rest of England. Of all trips, 30% are “new” outdoor recreation visits (where the individual would not have taken an outdoor recreation trip instead of the trip to Dartmoor).

Most importantly for our purposes, the calibrated ORVal model allows us to make predictions regarding visits from the expanding populations of the 8 neighbouring

LADs (see Table 1). We can see that the increasing populations in those LADs will result in the number of visits growing from an estimated 7,110,903 in 2014 to an estimated 7,983,217 in 2039, a growth of 12.3%.

Table 1: Growth in predicted visits to Dartmoor National Park 2014-39

LAD	2014	2019	2024	2029	2034	2039	Change 2014-39
East Devon	210,908	224,005	240,233	256,727	271,443	278,587	32.1%
Exeter	429,031	446,877	459,191	477,393	492,139	506,672	18.1%
Teignbridge	1,899,369	1,937,994	1,983,966	2,033,513	2,078,499	2,136,734	12.5%
West Devon	1,500,946	1,560,296	1,577,714	1,599,585	1,617,671	1,650,840	10.0%
Mid Devon	230,784	234,852	239,714	244,713	251,192	257,132	11.4%
Torbay	473,268	481,883	494,208	508,203	521,194	533,101	12.6%
Plymouth	1,374,116	1,413,406	1,438,915	1,476,701	1,506,000	1,532,663	11.5%
South Hams	992,481	1,015,249	1,029,116	1,050,436	1,067,131	1,087,488	9.6%
Total:	7,110,903	7,314,562	7,463,057	7,647,271	7,805,269	7,983,217	12.3%

3.2 PREDICTING RECREATIONAL ACTIVITY ACROSS DARTMOOR

While the ORVal model provides us with an insight into the distribution of visits across Dartmoor, it does not tell us anything about their subsequent activities. Insights on this can be obtained from the Monitor of Engagement with the Natural Environment (MENE), a survey of recreation day visits taken by English residents to the upland national parks of England. From the MENE survey we know that 81% of visitors come to Dartmoor for roaming recreation (e.g. walking, biking, horse-riding). The remaining 19% visits for activity-focused recreation, where individuals travel to a particular destination to undertake an activity such as fishing, eating out or visiting an attraction, as well as "other" unspecified activities. By far the most popular recreation type is "walking or running", with 78% of all visitors visiting Dartmoor for this reason. When predicting future recreational activities across Dartmoor, we make the assumption that the patterns of activity in the future will remain similar to those suggested by the MENE data.

In order to translate predictions of visits to National Park access points into measures of intensity of use of the Dartmoor landscape we developed predictions of where and how far visitors travel through that landscape. This is done separately for

roaming recreation and activity-focused recreation. For roaming recreation, we assume a Gaussian distribution, a statistical distribution which captures the fact that most visitors walk average distances (of around 9km), and increasingly smaller proportions of visitors taking longer and shorter walks. For activity-focused recreation we use an exponential function, assuming most people will transport themselves to an access point in proximity of the location in which they wish to undertake their leisure activity (median walking distance +-2km), with fewer individuals walking longer distances to reach the location of their activity. Using this information on walking distances, we can then build up estimates of the intensity of use of different locations across the Dartmoor landscape. Since our eventual focus will concern possible levels of disturbance caused by recreation on Dartmoor, we choose to illustrate footfall intensity by examining activity on the busiest days of the year. To that end we extract the ORVal visit predictions for a peak hour during a weekend day in the height of summer.

Figure 2 provides an illustration of footfall intensity estimates made for the 2019 population predictions at a time of peak activity on a summer weekend.

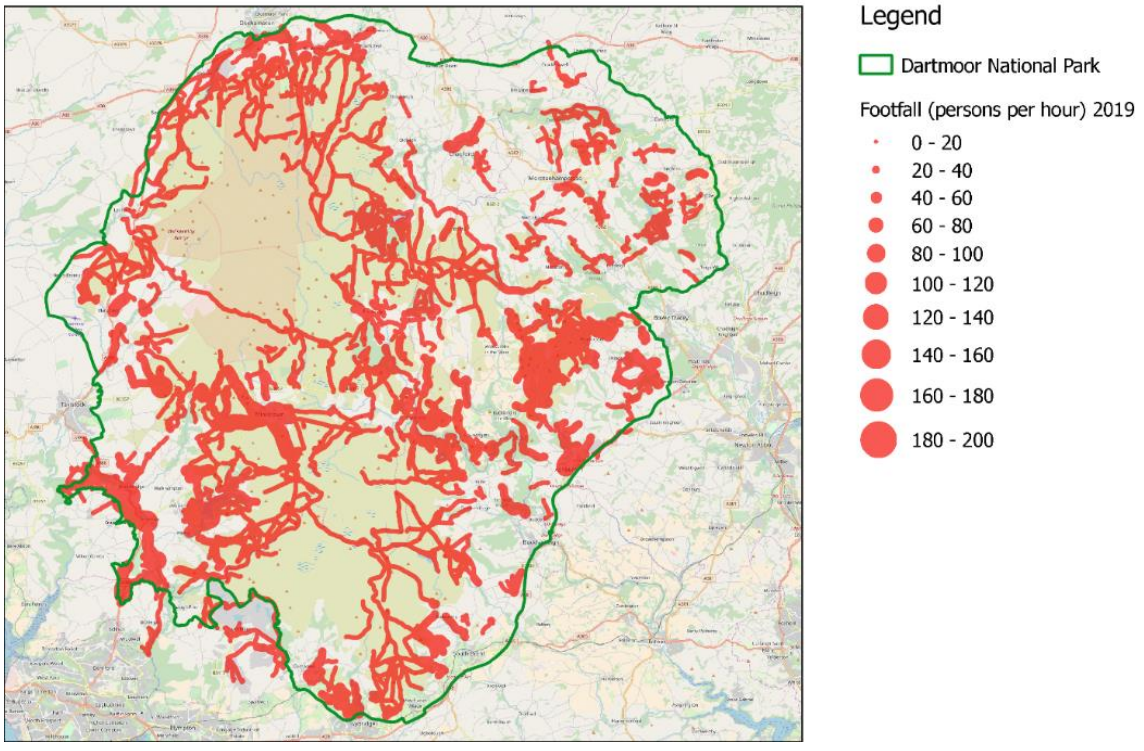

Figure 2. Predictions of peak hourly (summer weekend) footfall across Dartmoor in 2019.

While it is difficult to summarise the detail of these spatialized predictions, it is clear from Figure 2 that a number of high intensity footfall areas exist across the National Park. For example, areas which stand out are those around Haytor, Princetown and

Burrator, though other areas of intensive use are also evident. Applying the same methods to the populations expected in future years allows us to make predictions as to how footfall intensity might increase across the National Park over time. Those predictions of growth in footfall are illustrated in Figure 3. Please note that the scale of the size of symbols for illustrated footfall has changed from that in Figure 2 which shows absolute levels in 2019.

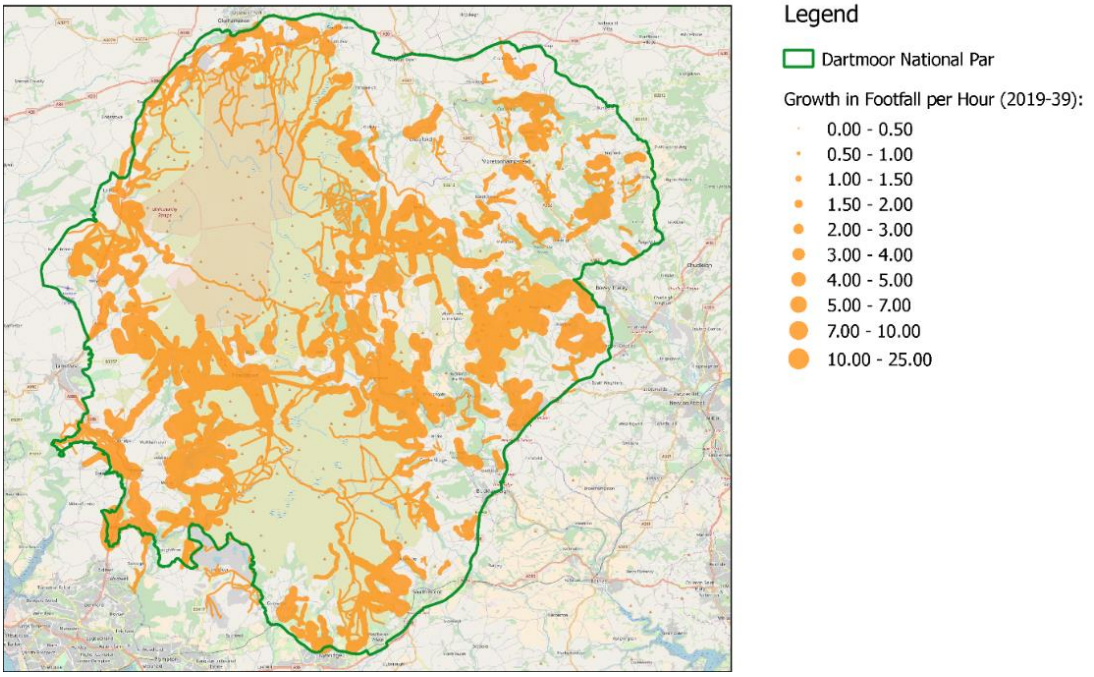

Figure 3. Growth in footfall (increase in persons per hour at peak times) across Dartmoor from 2019 to 2039.

From Figure 3 it is clear that fairly substantial increases in footfall intensity are expected in several locations across the National Park with peak increases of around 25 persons per hour at peak times. Not surprisingly, the locations attracting the largest increases in footfall are those that are also currently most attractive to visitors. The prediction algorithms also allow us to disaggregate the growth in footfall intensity by the local authority area from which visits arose. From such analysis it can be seen that growth in footfall tends to be greatest in areas within the National Park that fall within or near the corresponding LAD, with for example Teignbridge predominantly contributing to the footfall growth in the east of Dartmoor, and Plymouth to the southwest of Dartmoor. For LADs stretching further away from Dartmoor, such as East Devon and Mid Devon, growth in footfall is more evenly spread across the National Park. Maps of footfall disaggregated by LAD are available in the full version of this report

4 BENEFITS OF DARTMOOR

4.1 WELFARE BENEFITS

In social cost-benefit analysis (as prescribed, for example, in the Treasury Greenbook) enjoyment can be quantified by translating it into a measure of Willingness to Pay (WTP), a measure of welfare. In this context, WTP measures the maximum amount of money that an individual would be prepared to give up in order to ensure that they could visit a recreation site on Dartmoor. The ORVal model (discussed above) can be used to calculate the WTP of each adult in England for each recreation site on Dartmoor.

Table 2 provides estimates of current and predicted future welfare benefits derived from recreational use of Dartmoor for the residents of each of the eight LADs. The headline figures are that Dartmoor currently provides an estimated £25.6 million of welfare benefits to the residents of the 8 neighbouring LADs each year. By 2039, this is predicted to rise from to £28.1 million; an increase of annual welfare benefit of £2.5 million. Detailed information on the principles and methodology behind the WTP methodology, and on the welfare generated by Dartmoor recreation disaggregated by socioeconomic segment are given in the full report.

Table 2: Welfare predictions for Dartmoor recreation day visits from neighbouring Local Authority Districts for 2019 population estimates

Region	2019 Welfare (£2016)		2039 Welfare (£2016)		Change in annual Welfare 2019-39 (£2016)
	Total	Per Head	Total	Per Head	
East Devon	970,758	8.18	1,200,070	8.77	229,313
Exeter	1,807,818	16.60	2,051,361	16.61	243,543
Teignbridge	6,417,551	58.43	7,116,188	56.97	698,637
West Devon	4,728,658	95.59	5,025,164	93.10	296,506
Mid Devon	928,539	14.03	1,017,552	13.84	89,013
Torbay	2,050,026	18.17	2,267,994	18.17	217,968
Plymouth	5,351,929	24.10	5,803,982	23.99	452,053
South Hams	3,376,965	46.41	3,631,514	45.96	254,548
Total:	25,634,263		28,115,865		2,481,582

4.2 ACTIVITY BENEFITS

Another benefit provided by the National Park arises from the potential health gains of that recreational activity carried out on Dartmoor. Our analysis of footfall allows us to predict the sum of distance walked by all visitors and for those from each neighbouring LAD (Table 3). Using existing data on average stride length and energy expenditure we then estimate energy useage and fat burn by Dartmoor visitors. The headline figures from Table 3 are that access Dartmoor facilitates recreational activity that results in the visiting population of England burning an estimated 129,030 kg of fat each year. Just under 100,000 kg of that fat-burn is realised by residents of the local LADs.

Table 3. Aggregate physical activity levels from predicted recreational activity on Dartmoor in 2019

Region	Distance (km)	Steps (million)	Energy Expenditure (kJ)	Fat Burned (kg)
England	18,376,854	24,502	4,774,098,770	129,030
East Devon	304,121	405	79,007,079	2,135
Exeter	694,528	926	180,430,554	4,877
Teignbridge	3,267,405	4,357	848,834,744	22,941
West Devon	3,579,904	4,773	930,018,622	25,136
Mid Devon	301,920	403	78,435,513	2,120
Torbay	827,370	1,103	214,941,293	5,809
City of Plymouth	3,580,704	4,774	930,226,352	25,141
South Hams	1,686,138	2,248	438,039,519	11,839

One thing to note about the figures in Table 3 is that we cannot assume that without Dartmoor the physical activity would not instead have been undertaken at some other outdoor recreation site. One reasonably defensible assumption is that the physical activity benefits of trips to Dartmoor that are 'new' (i.e. where the individual would not have taken an outdoor recreation trip instead of the trip to Dartmoor) are wholly attributable to the existence of the recreation facilities of the National Park. From our ORVal estimates we know the number of new visits to be around 30% of total visits (see section 3), such that a good lower bound estimate of physical activity benefits would be 30% of the figures in Table 3.

5 COSTS TO DARTMOOR

5.1 PATH EROSION

Increased footfall on Dartmoor has the potential to contribute to increased levels of path erosion and soil compaction. We used data from Coleman (1981), which provides a comprehensive assessment of factors impacting on footpath erosion in the Lake District, to make predictions regarding rates of path erosion on Dartmoor. The results of that analysis are visualised in Figure 4. Erosion risk is focused on steep paths particularly in those areas experiencing the most predicted footfall. We calculated that by 2039 rising visitation might be responsible for an additional 74,135m^3 of vegetation being damaged from recreation pressure widening footpaths. Moreover, an additional 10,854 m^2 of bare ground might be exposed along the path network. Some 250m of path will experience increased gullying in excess of 5cm depth and 42km of path will experience gullying of more than 1cm. While a Dartmoor-specific primary study would likely be needed to more clearly define the nature of erosion problems across the National Park, the analysis suggests that the magnitude of visitation increase will likely have impacts across wide areas on trampling of vegetation with substantial more localised erosion of paths particularly on steep sections of paths.

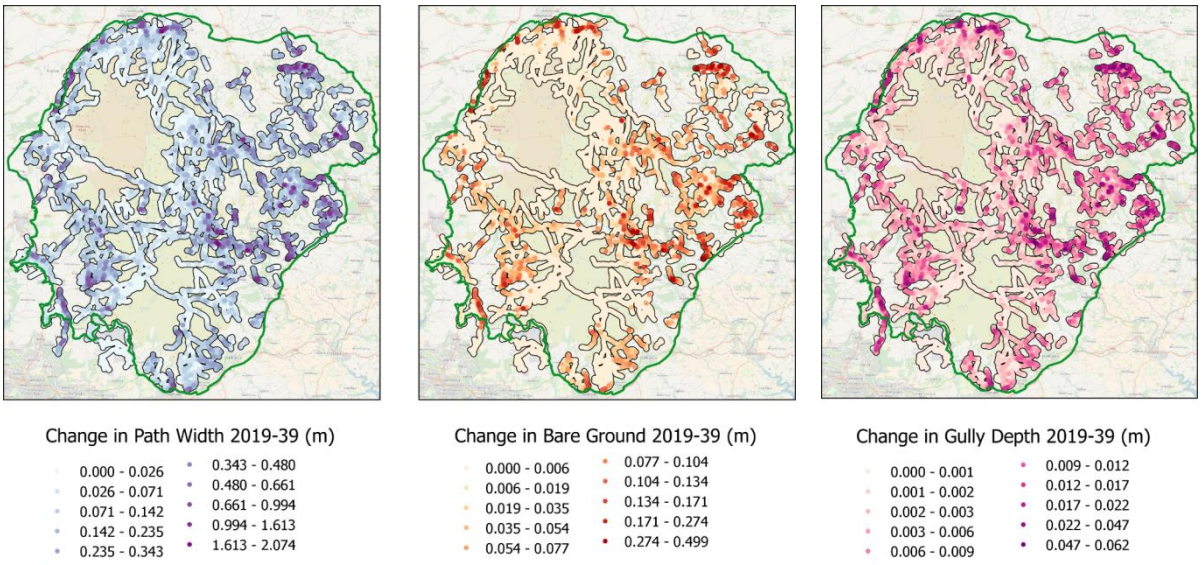

Figure 4. Predictions of locations of increasing erosion by 2039

5.2 WILDLIFE DISTURBANCE

To evaluate the potential impacts of recreation on Dartmoor wildlife, we reviewed the existing scientific literature and carried out analyses based on questionnaires with local species experts. An overview of findings and suggested mitigation measures from the scientific literature can be found in the full report. The species questionnaires aimed to understand the local requirements, distribution and sensitivity to a range of recreational activities for key Dartmoor species. Key species were selected from two local publications; the State of Dartmoor's Key Wildlife, and the Devon Special Species List. The selected species have local, national or international importance, and represent a broad range of habitats and species groups.

Questionnaires and species impact case studies were completed for: *Adder, Blue Ground Beetle, Bog Hoverfly, Cuckoo, Dartford Warbler, Dipper , Dunlin, Fairy Shrimp, Greater Horseshoe Bat, Hen Harrier, High Brown Fritillary, Marsh Fritillary, Narrow-bordered Bee Hawkmoth, Nightjar, Otter, Pearl-bordered Fritillary, Peregrine Falcon, Plants* (generic overview across lower and higher plants)*, Raven, Red Grouse, Ring Ouzel, Salmon, Skylark, Snipe, Southern Damselfly, Whinchat and Wood Warbler.*

Full species case studies and hotspot maps are excluded from this summary report due to the sensitivities of releasing such information for some species. An overview of findings is provided in Table 4.

Table 4. Activity types and impacted key species

Activity type	Affected key species

Walking/ hiking/ running	• Butterflies & moths
	  ▪ low levels of disturbance to individuals
	  ▪ trampling of key vegetation or food plants under high footfall
	• **Cuckoo** (disturbance to breeding behaviour and fledglings)
	• **Dartford Warbler** (reduced breeding performance)
	• **Dunlin** (potential disturbance but currently low spatial overlap with recreation)
	• **Nightjar** (disturbance leading to nest failure)
	• **Plants** (trampling damage)
	• **Raven** (potential future breeding disturbance)
	• **Ring Ouzel** (disturbance and nest failure)
	• **Whinchat** (breeding disturbance)
	• **Wood Warbler** (disturbance to territory settlement and breeding)

Activity type	Affected key species
Large events	• **Adder** (disturbance to breeding areas) • **Butterflies & moths** (trampling of key vegetation or foodplants) • **Cuckoo** (prolonged disturbance & displacement of birds from sites) • **Dartford Warbler** (prolonged disturbance) • **Dunlin** (prolonged disturbance) • **Plants** (trampling damage) • **Red Grouse** (prolonged disturbance) • **Ring Ouzel** (prolonged disturbance) • **Skylark** (increased trampling risk due to nests in open vegetation) • **Southern Damselfly** (trampling of key habitat) • **Wood Warbler** (breeding disturbance and trampling risk)
Dog-walking	Effects similar to walking with additional negative effects,, e.g: • **Adder** (disturbance) • **Cuckoo** (disturbance to breeding behaviour and fledglings) • **Ground-nesting birds** (generally more easily disturbed by dogs than by humans only, increased flushing at nests can lead to increased predation risk) • **Plants** (potential nutrification)
Mountain-biking	• **Nightjar** (disturbance from off-road cycling in conifer plantations) • **Plants** ("trampling" damage) • **Wood Warbler** (potential breeding disturbance)
Horse-riding	• **Plants** (trampling damage)
Increased car traffic	• **Adder** (occasional collision death) • **Butterflies & moths** (occasional collision death) • **Cuckoo** (occasional collision death) • **Greater Horseshoe Bat** (collision death, disturbance to commuting from lights at night) • **Otter** (occasional collision death) • **Plants** (possible indirect effects due to reduced air quality)
Wildlife watching/ naturalists	• **Butterflies & moths** (illegal collection) • **Hen Harrier** (disturbance of roost sites by birdwatchers) • **Ring Ouzel** (disturbance and nest site trampling can lead to displacement and reduced breeding success) • **Wood Warbler** (prolonged breeding disturbance due to information-sharing between photographers)
Fire/arson	• Butterflies & moths (habitat loss) • **Plants** (vegetation loss)
Camping/ barbecues/ picnics	Causes prolonged disturbance and/or displacement, such as: • Most **breeding birds** when activity takes place in/near territory
Kayaking/ swimming/ fishing	• **Dipper** (potential disturbance to territorial behaviour, foraging behaviour and fledglings) • **Plants** (loss of lower plants from stones at access points, trampling)

Activity type	Affected key species
	• **Salmon** (exploitation from illegal fishing, potential disturbance from dams created by visitors)
Caving	• **Greater Horseshoe Bat** (disturbance if roosting or hibernating in caves)
Climbing/ bouldering	• **Peregrine Falcon** (reduced breeding success) • **Raven** (breeding disturbance) • **Ring Ouzel** (potential for future disturbance at breeding sites)
Illegal raves	General disturbance to wildlife, e.g. Nightjar
Letterboxing/ geocaching	• **Plants** (loss of lower plants from stones) • **Ring Ouzel** (prolonged disturbance)
Joy-riding (off-road vehicles)	• **Southern Damselfly** (damage to key habitat)

Based on the questionnaire results, we assigned the key species into three levels of sensitivity to recreation activities, using the following categories:

Green: recreation impact unlikely. Species are either:

- not likely to be affected by any of the listed recreational activities, or
- spatial overlap between recreation and species occurrence is minimal, therefore substantial conflict is unlikely

Orange: recreation impact possible or minor

- Minor or localised recreation impacts could be a concern
- Strong effects unlikely (unless there are major changes in recreation patterns)

Red: recreation impact high or likely

- Adverse impacts have been recorded
- Spatial conflict and recreational impacts deemed likely

The sensitivity categories for each species are shown below. Sensitivity colours are assigned in the context of the current status of the species on Dartmoor, and the level of recreational use currently seen and realistically expected in the future for Dartmoor. These groupings are therefore specific to Dartmoor, would need to be reviewed periodically when recreational patterns or species distributions change, and would not necessarily be applicable to other locations.

Green: Blue Ground Beetle, Bog Hoverfly, Fairy Shrimp, Otter, Peregrine Falcon, Snipe

Orange: Adder, Hen Harrier, High Brown Fritillary, Marsh Fritillary, Narrow-Bordered Bee Hawkmoth, Pearl-Bordered Fritillary, Plants, Salmon, Skylark, Southern Damselfly

Red: Cuckoo, Dartford Warbler, Dipper, Dunlin, Greater Horseshoe Bat, Nightjar, Raven, Red Grouse, Ring Ouzel, Whinchat, Wood Warbler

For the species deemed sensitive to recreation impacts based on expert opinion (listed as "red" above),we used our data on predicted footfall data to map the likelihood of recreation impacts in future years. Hotspot and/or distribution information was not available for all species, and this mapping was therefore conducted only for Ring Ouzel, Red Grouse, Dunlin, Greater Horseshoe bat, Dipper, Wood Warbler, Nightjar and Cuckoo. A combined map of hotspots for these species and areas of growth in footfall is shown in Figure 5, illustrating areas where key species and recreation are predicted to come into increased conflict.

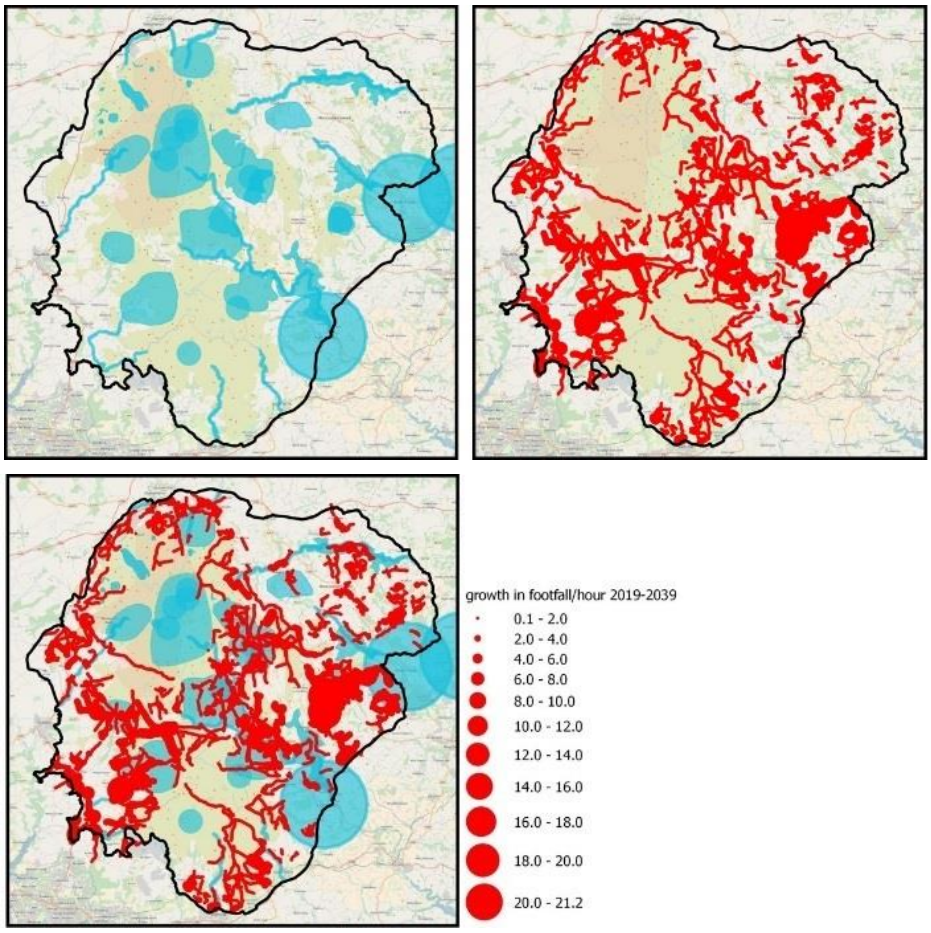

Figure 5. Key species hotspots (Cuckoo, Dipper, Greater Horseshoe Bat, Nightjar, Raven, Red Grouse, Ring Ouzel and Wood Warbler) (top left), predicted growth in footfall per hour 2019-39 (top right), and combined (bottom panel)

Based on Figure 5, we highlight 4 vulnerable wildlife locations where particularly strong increases in footfall are expected between now and 2039; the areas around Burrator, Dart Valley/Venford Reservoir, Haytor and Warren House/Soussons/ Fernworthy.

Our analysis from the ORVal model showed that visitors from a given LAD tend to focus trips to areas in the National Park that are closest to their location of residence. To understand from where the visitor growth in the four vulnerable areas will originate, the growth in footfall was mapped separately for each LAD. Findings are discussed below and associated maps are given in the full version of this report.

- **Burrator area**: The growth in footfall around this area is predicted to originate almost exclusively from the Plymouth, West Devon and the South Hams LADs. The highest increase in footfall is expected from the Plymouth area.
- **Dart Valley and Venford Reservoir**): The largest increase in footfall is predicted to come from the Teignbridge local authority area, with the Exeter, East Devon, Torbay, South Hams and Plymouth LADs also showing substantial growth in footfall across much of the Dart Valley and Venford Reservoir area.
- **Haytor area**: Increases in footfall around Haytor are predicted to originate from all local authority areas. The figure shows that visitors from the Teignbridge area are making the largest contribution to this growth
- **Warren House/Soussons/Fernworthy**: The total predicted hourly growth in footfall in this area appears to consist of visitor growth originating from all local authority areas, which is perhaps unsurprising given the central Dartmoor location of the Warren House/Soussons/Fernworthy area.

The vulnerable areas described above are examples only; wildlife and increased footfall may come into conflict at numerous other sites, also for species which were not investigated in this study. Furthermore, based on this information, precise effects of increased footfall on these species cannot be predicted. Threshold levels of footfall, above which negative effects occur, are largely unknown, and will differ between species, time of year, and other factors such as vegetation type or site geography. Detailed studies would be needed to derive species-specific recommendations on harmful footfall levels, but the information here can nonetheless be used to inform basic management decisions. For example, mitigation can be prioritised in the indicated vulnerable areas, as larger changes can be expected on those sites compared to other areas of Dartmoor.

5.3 MITIGATION MEASURES

Recommendations for potential measures for mitigating the impacts on wildlife are briefly listed below.

Several existing mitigation measures which are currently used by DNPA were listed by species experts as desirable. These include the existing policy around discouraging access to rare bird nesting area, prevention of illegal raves, and the policy of keeping details of nesting and/or roosting locations of rare birds (such as Hen Harrier) out of the public domain. The regulation of large events was also identified as an important policy; several bird species experts expressed serious concerns over the possible impacts on breeding birds resulting from the prolonged disturbance arising from such events. Both the consulted Dartmoor species experts and the information from the reviewed scientific literature highlight "dogs on leads" policies as an important mitigation measure. A "dogs on leads" policy is already in existence and can benefit a wide range of ground-nesting bird species, as well as minimising dog-Adder conflict, and the evidence, albeit limited, supports the continuation and possible extension (and further efforts for reinforcement) of this policy.

A number of targeted, smaller scale interventions were suggested which would be relatively straightforward to implement and are likely to benefit a number of key species. This includes the installation of Dipper nestboxes, an outreach initiative to educate the public on wildlife disturbance, and the use of temporary path closures to reduce footfall in sensitive areas.

In addition to the targeted mitigation measures outlined above, wider habitat management is key in providing sufficient suitable habitats for wildlife. Habitat enhancement or habitat creation can be used in strategic locations away from recreation hotspots in order to maximise the availability of habitat for key species. More generally, encouraging a rich diversity of vegetation types across the moor will ensure the availability of suitable habitat for a wide range of species. For example, avoiding burning in selected patches can create a mosaic of higher shrubbery to support a range of invertebrates and birds. Where used in targeted locations, this could also help reduce habitat penetrability for dogs and humans, and can therefore be used strategically to discourage recreational activity and prevent footpath creation or footpath widening in areas of concern.

A further broad mitigation measure is the active creation of "wildlife refuge areas" where recreation is discouraged. Temporary path closures can be used to prevent visitors entering sites where vulnerable species are found. However, full access restrictions are often not a feasible management option, and a range of alternative techniques can be used to discourage visitation to particular areas. As mentioned above, using patches of higher vegetation around key wildlife sites can reduce visitor numbers by reducing the accessibility of sites. Reduction (or prevention of expansion) of parking availability, and the provision of alternative access points can have similar effects. Signposting along access points and footpaths can be used to encourage visitors to take specific routes, thereby taking a land-sparing approach to recreational activities. The active creation of such "wildlife refuge areas" is not recommended to be necessary on the high open moors, which are natural refuges due to their inaccessibility and subsequent low levels of footfall. Areas which may be particularly suitable for the interventions outlined above are sites which are important for wildlife whilst not showing high predicted levels of increased footfall. Examples include the Tavy Teign and Bovey Valleys. On key conflict sites such as Warren House and Venford/Dart Valley, vegetation management and signposting could be used to encourage visitors towards certain areas whilst maintaining local wildlife refuges in these areas. A big honeypot site such as Haytor, which is predicted to experience large increases in visitor numbers over coming decades, may be a site of choice for the encouragement of recreation through promotion and the provision of additional access and facilities to draw visitors to this area, thereby sparing other sites. This can of course be combined with further access management (e.g. higher vegetation, footpath closures) at this site in order to discourage visitors from straying into nearby areas of conservation importance.

A number of the mitigation measures outlined above are currently being considered and/or implemented as part of the National Park's recreation strategy.

In addition to this report, an accompanying assessment on planning and legal systems was conducted in order to identify potential alternative income streams to fund mitigation measures. Further details can be found in the assessment report by Green Balance and Kristina Kenworthy.[1]

[1] Planning and legal advice – informing assessment of recreational impacts on Dartmoor National Park. Green Balance and Kristina Kenworthy. March 2018.

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Executive Summary

- Dartmoor National Park is enjoyed by large numbers of visitors. Significant new housing developments and population growth in the districts around Dartmoor will inevitably result in increases in the number of visitors to the National Park.
- The statutory purposes for National Parks (Environment Act 1995) are to i) "*conserve and enhance the natural beauty, wildlife and cultural heritage*" and ii) "*promote opportunities for the understanding and enjoyment of the special qualities of national parks by the public*".
- In connection with these statutory purposes, the aim of this report is to identify both how the expanding population of Dartmoor's hinterland will benefit from the National Park as a recreational resource and also how the pressure of the additional visits coming from those new residents will impact on the National Park's environment.
- The report is compiled by academics from the SWEEP project (www.sweep.ac.uk) at the University of Exeter, and draws on secondary data, modelling capacity and on expert inputs in order to present a comprehensive assessment of the recreational future of Dartmoor..
- The first major contribution of this report is to construct spatialized predictions of population change in the Dartmoor hinterland from 2014 to 2039. Those predictions draw on Office of National Statistics population projections augmented by details of proposed property developments described in the Local Plans of the eight Local Authority Districts (LADs) that surround the National Park.
- To understand how new residents of the region might use Dartmoor, the spatialised population projections have been coupled with the Outdoor Recreation Valuation (ORVal) tool. ORVal is a sophisticated recreation demand model developed by the LEEP institute at the University of Exeter. As part of this project a bespoke calibration of the ORVal tool was developed and used to predict current and future patterns of visits to the array of recreation sites across Dartmoor National Park.
- The model indicates that Dartmoor is currently the backdrop for over 7 million day trips per year from residents of the eight neighbouring LADs. Moreover, increased populations in those LADs will result in more than 870,000 additional annual visits to Dartmoor per year, a rise of some 12%.
- The report also describes the development of a second bespoke modelling tool that extends the ORVal estimates of visitation into estimates of intensity of footfall through the National Park. That model used evidence from various

sources to approximate how far visitors might travel through the paths network during their visits. The resulting estimates of the spatial dispersion of visitors and the intensity of footfall across the National Park allows us to address a number of questions regarding the impact of recreation on Dartmoor.

- The report addresses both the benefits and the costs of increased recreation activity on Dartmoor. With regards to benefits, a key measure is that of economic welfare. Welfare refers to the sense of well-being or utility experienced by an individual. Economic welfare is a figure capturing the monetary equivalent of this welfare enjoyed by visitors from their visits. Economic welfare can be directly estimated using the calibrated ORVAl tool. Indeed the model indicates that Dartmoor is currently the source of £25.6 million of welfare benefits to the residents of the 8 neighbouring LADs each year and that as a result of population increases that number will likely rise to £28.1 million by 2039; an increase in annual welfare of £2.5 million..
- Those welfare benefits are not evenly distributed across the neighbouring LADs. Rather the largest economic welfare values are realised in those LADs with significant populations in and around Dartmoor including Teignbridge, West Devon and Plymouth.
- The report also attempts to quantify the health benefits of the physical activity enabled by recreational access to the National Park. The footfall model provides prediction as to how far visitors to Dartmoor might be expected to walk in the National Park. Translating walking distances into energy expenditure provides an estimate of the level of fat burned by visitors, a quantity amounting to 100,000 kg of fat each year for the residents of the eight LADs neighbouring Dartmoor.
- Increased recreational activity on Dartmoor also generates the possibility of increased environmental and management costs. Transferring findings from a detailed study of the English Lake District, the report uses the footfall intensity estimates along with measures of path slope and altitude to predict rates of footpath erosion. Our analyses suggest that increasing recreational pressure on Dartmoor may result in 10,854 m^2 of bare ground being exposed along the path network and increased gullying along 42km of path.
- With regards to wildlife the research team carried out an extensive review of literature on the disturbance impacts of recreation. That review indicates that recreation impacts are complex and that it is difficult to make generalisations regarding how wildlife responds to recreation pressures. The report provides some detailed pen pictures of a selection of studies that are most relevant to the environment and wildlife of Dartmoor.
- To better understand the potential for recreational disturbance of wildlife on Dartmoor a selection of species of local, national and international importance,

were identified from two local publications, 'The State of Dartmoor's Key Wildlife' and the 'Devon Special Species List'. For each species a recreation impact questionnaire was conducted with a local expert. The questionnaire gathered information on the distribution of each species across the Dartmoor landscape and sought insights as to whether and how exposure to increased recreation activity might impaction on the species population.

- Our analysis identifies twelve species that stand as examples of species that might be vulnerable to disturbance from increased intensity of recreational activity. Examples of species of particular concern include Cuckoo, Nightjar, Ring Ouzel and Wood Warbler. Activity types which have negative effects differ between species, but walking, dog-walking and large events are key concerns across many of the investigated key species.
- Overlaying the distributions of those species with our estimates of increasing visitor pressure across the National Park allows us to highlight some species that might be a focus of concern and the locations in which they are made vulnerable by rising recreation pressures. Those locations include the areas around i) Burrator, ii) the Dart Valley and Venford Reservoir, iii) Haytor, iv) Warren House, Soussons and Fernworthy.
- At these sites, an increased conflict between recreation and wildlife can be expected, and mitigation measures could therefore be prioritised there. Mitigation measures derived from both expert opinion and past research are outlined in the report. Measures suggested to be beneficial to a broad range of species include (temporary) access restrictions, management of large events, enforcement of the dogs on lead policy and public education.
- Recommendations for future data collection and research are discussed. These include further study to establish footfall thresholds for wildlife disturbance, an assessment of footfall intensity in relation to erosion patterns, and a quantification of recreational activities across the National Park.