

# Promoting responsible Ancient Woodland use: Rapid evidence review

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# 1 Aims

Work package 4 of the NCF Impacts of development on Ancient Woodlands project is intended to answer the following research question:

RQ6: What issues and values would influence the actions and behaviours of the public towards responsible use of Ancient Woodlands (AW) near development?

Prior to selecting the behaviours and publics of interest to this inquiry, it is important to undertake a review of the existing evidence on the impact of public behaviours on AWs. This is necessary for prioritising those behaviours with the most detrimental impact on AWs and summarising the evidence-based interventions for behaviour change in these contexts. The review will therefore focus the subsequent research on the priorities and behaviour change mechanisms identified, including informing case study selection.

This review will address the following:

Q1: What are the public behaviours with the greatest negative impact on AW and who are the key groups undertaking these behaviours?

Q2: Is there evidence for the motivations behind these behaviours and interventions that change these behaviours?

Given the specificity of these questions, literature from other relevant topics (i.e. non-ancient woodlands, use of green spaces, environmental behaviour change) will be drawn on, especially where evidence specific to Ancient Woodlands is not available, which is often the case.

# 2 Method

Searches were entered into Scopus and the Forest Science Database.

## Impact of public behaviours on woodland ecological health and quality

Although there has been research into the effect of development on Ancient Woodlands, including reviews (e.g. Carr 2021), this work has tended to focus on loss, deterioration and fragmentation of Ancient Woodlands, and there has been less coverage of the impact of public behaviours specifically. This is true when looking for literature that covers the broader context of 'woodlands' in general. Marzano & Dandy (2012) conducted an extensive review of the literature on forest recreation and wildlife disturbance. This review mirrored some of the search strings

used in that review, but to avoid duplication with that study, search results prior to 2011 were excluded. Based on titles and abstracts, papers were included if they addressed the impact of humans and companion animals on the ecological health of woodlands. No other exclusion criteria beyond relevancy and date of publication were used due to the sparsity of literature on the areas of interest.

Search strings used were:

- (public OR visitors) AND (behaviour OR impact OR recreation) AND woodlands
- (public OR visitors) AND (behaviour OR impact OR recreation) AND forests AND UK – UK added as otherwise the string returned >6,000 hits
- Recreation AND disturbance AND woodlands AND (cycling OR biking OR dog OR “bird watching” OR “off-road vehicles” OR “quad biking” OR “car rallies” OR motocross OR walking OR hiking OR “horse riding” OR camping OR “visitor behaviour” OR “visitor management”)
- Woodlands AND impact AND (arson OR vandalism OR “dog waste” OR compaction OR trampling OR disturbance OR dumping OR waste OR littering OR fly-tipping OR noise OR “artificial light” OR “removal of dead wood” OR “garden invasive species” OR “predation by pets” OR “anti-social behaviour”)

The search strings returned 1,166 results, however most were irrelevant. Of the papers found, 27 were considered relevant.

Marzano & Dandy (2012) highlight that the majority of studies on visitor impact on woodlands focus on walking in the relation to trampling vegetation, compacting soils and disturbing birds. This was also true of the evidence this review found, with the addition of some studies looking at how recreational forest use impacts larger mammals such as deer (Coppes & Braunsch 2013, Scholten et al. 2018, Dixon et al. 2021, Drimaj et al. 2021) and some considering recreational use beyond walking, such as biking (Scholten et al. 2018) and off-road driving (Pigeon et al. 2016).

A summary of the included papers is presented in Table 1 below.

Most papers focused on the impact of public behaviours, such as trampling, compaction and wildlife disturbance, and as such, did not distinguish between recreational visitors and those with other motivations. One avenue for this work package would be to focus on paths in Ancient Woodlands, with particular attention to path design/management and mitigating the instances of people leaving the paths/creating informal paths (desire lines). This is an area in which the trade-offs between public access and biodiversity might be made explicit and explored

constructively. In addition, there are clear spheres of literature to engage with and contribute too, including with regards to potential interventions (see next section).

Alternatively, there are many potentially highly damaging public behaviours that are understudied in relation to their impact on woodlands, perhaps due to the lack of data on their prevalence in woodland contexts (but see Fechtnerová 2012 on illegal dumping in Czech forests). These include the spread of invasive species (including through the dumping of garden waste, c.f. Šipek & Šajna 2020), removal of vegetation (such as orchid collecting), littering (small litter, dog-waste, fly-tipping, c.f. Litter and littering in England 2018 to 2019 - GOV.UK ([www.gov.uk](http://www.gov.uk))), intensive foraging, removal of dead wood, vandalism and arson (Corney et al. 2008). This work package could explore the prevalence and perceptions of such behaviours in a few distinct case study sites where housing developments neighbour Ancient Woodlands.

The majority of the section that follows focuses on off-trail travel as it proved difficult to find relevant literature on the other behaviours discussed.

Table 1. Summary of research papers considering the impacts of human behaviour on woodland ecological health

Review Papers	Impact of behaviours on woodlands
Marzano & Dandy 2012	Most studies focus on walking and impact on soils, vegetation and birds, very little on other wildlife. Limited evidence of long-term impact. Few studies on users' own perspective on their impact. Few studies on managing impacts. Need more research on what management actions work and could be accepted by the public.
Referowska-Chodak 2019	Focus on threat of human activities to forests including deforestation and other large scale impacts but also intensive use by humans. Trampling, large-scale foraging, littering, vandalism, arson and disturbing wildlife are addressed but not compared or ranked.
Social Science Papers	Impact of behaviours on woodlands
Jones & Rotherham 2012	Long-term (30 year) case study in Sheffield, England. Showed ability of ancient woodland flora to reappear, however also issues of human encroachment from nearby housing. Key impacts include introduction of exotic/potentially invasive species and destruction of last refuges of rare woodland indicator plants. As such, public relations are as important as ecological management and this is challenged by the erosion of public services.
Levêque et al. 2015	Social perceptions of recreational impacts on amphibians such as great crested newts in Scotland. Most surveyed did not believe they had a significant impact and blamed other activities but did support management. They support communications such as codes of conduct and educational programmes.
Lupp et al. 2022	Perceptions and preferences of woodland visitors in Munich. Preferences for mixed forests, but 'small details' such as single trees, colour and shrubs also contributed to positive perceptions.

Social Science Papers continued	Impact of behaviours on woodlands
Dick et al. 2022	Spatial model of ecosystem services and recreation trade-offs in Cairngorms, Scotland. Explored through interviews with protected area managers and recreationalists. Park managers seeking to understand why recreationalists value an area, in order to balance trade-offs, but recreationalists have diverse needs.
Hague et al. 2022	Perceptions of a woodland area in Scotland. Participants focused on human benefits and emphasised a development logic – seeking that ‘more’ be made of the woodland. As such management for conservation alone may not be acceptable.
Ecological Papers	Impact of behaviours on woodlands
Arnesen & Lyngstad 2012	Trampling especially impactful on soil and vegetation in high moisture areas, though some species more tolerant than others (review of Norwegian evidence). Need more surveys of impacts and research on regulating human movement.
Sikorski et al. 2013	Forest areas in Warsaw parks were surveyed for their vegetation. The areas with public access were found to have some forest species replaced by cosmopolitan non-forest species. This may be the result of human induced compaction and change in soil pH and moisture.
Coppes & Braunisch 2013	Identification of ‘conflict-sites’ where humans might disturb wildlife requirements (Germany). Modelled where recreation users are likely to go off-trail in winter and where this overlapped with the habitats of capercaillie and red deer. Recreationists most likely to go off trail where there were signposts for (closed) summer trails and where the vegetation was successional. Slope and increased canopy cover were negatively correlated

Ecological Papers continued	Impact of behaviours on woodlands
Huhta & Sulkava 2014	Three year study of bird disturbances by nature tourism in a national park in Finland. Human associated species (i.e. corvids) high in urbanised areas however the abundance of virgin forest species did not differ across areas studied. They suggest that the abundance of 'urban exploiter species' could act as an indicator to monitor impact of urbanization/recreational pressure.
Rodríguez-Prieto et al. 2014	Modelled disturbance of forest birds by different trail designs, use rates and management of invasive vegetation in Indiana, USA. Appropriate management differed by bird species, which cautions against a single species approach, and invasive vegetation removal did not have a cumulative effect.
Wiedmann & Bleich 2014	Distribution and abundance of bighorn sheep was monitored across a hiking trail in North Dakota, USA. Displacement, abandonment and decreased abundance was observed in response to unpredictable recreational use at one site, compared with other sub-populations along the trail. Severity and predictability of human activities was important, as was the existence of spatial separation between recreationists and lambing habitat.
Thompson 2015	Trails in publicly owned natural areas in the USA were surveyed for the density of forest birds, especially ground nesting birds. These birds were positively influenced by the amount of trail-free refuge habitat. This has implications for managing the trade offs between biodiversity and public access.
Ballantyne & Pickering 2015	Comparison of impact of management created with informal trails, looking at trail surface, loss of forest strata and changes in tree structure in Australia. Informal trail had poorer surfaces and were poorly located. Wide informal trails and formal hardened trails had a similar impact on canopy cover and tree density. Trade-offs as few formal trails might mean a proliferation of informal trails.

Ecological Papers continued	Impact of behaviours on woodlands
Vakhlamova et al. 2016	Urban and suburban forests in Kazakhstan were surveyed for visitor frequency and the impact of recreational disturbance including trampling and damage to vegetation as well as waste deposits. Visitor frequency did not differ in the summer, however visitor demographics and activities were distinct. In urban forests, plant species richness was lower and there was a high proportion of alien plant species. Suburban forests were less affected.
Pigeon et al. 2016	Off-road vehicles are a factor in the disturbance of caribou abundance in Canada. Off-road vehicle use was mainly associated with topography and vegetation that eased travel, whereas recreation access or hunting activities were not associated. They recommend restrictions on low vegetation and dry areas of caribou ranges.
Bötsch et al. 2017	Experimental test of effect of disturbance on birds in forest plots in France. Number of territories and species richness lower for disturbed plots. Birds sensitive to human presence, open-cup nesters and above-ground foragers most affected. Even low levels of human recreation can alter territory establishment.
Bötsch et al. 2018	Comparison of density of birds and species richness between frequently and rarely visited forests in France. Highest impact close to trails and impact varied by traits of birds. Suggest visitor guidance and avoidance of new trails in previously undeveloped habitats.
Scholten et al. 2018	Red deer pellets decreased in number close to mountain biking trails in Norway and red deer avoided areas within 40m of these trails. Camera traps showed fewer deer with increasing human activity (trail width) in daytime, with the effect seen more strongly in males.



Ecological Papers continued	Impact of behaviours on woodlands
Šipek & Šajna 2020	A survey in Slovenia of the public's awareness of invasive alien plant species and the prevalence of dumping garden waste in forests. Over 10% of respondents admitted to such dumping, and those who were aware of the negative consequences of this behaviour with regards to introducing alien plant species were less likely to improperly dispose of garden waste.
Dixon et al. 2021	Red deer faecal cortisol was highest on days with highest visitor numbers in a deer park in Cheshire, England.
Drimaj et al. 2021	In suburban forests in the Czech Republic, numbers of roe deer and wild boar were higher in disturbed than peaceful areas, likely due to the presence of a shrub layer in the former. However, the roe deer had adopted as two-peak activity approach (dawn and dusk) as a response, while the boar were entirely nocturnal to avoid humans.
Fitzpatrick et al. 2021	A model of red wood ant distribution was tested in Switzerland. Human disturbance was not found to be associated with their distribution.
Uzun et al. 2021	Long-term case study (40 years) of the impact of human use in a National Park in Turkey. Digital analysis of aerial photographs showed an increase in buildings, roads and bare areas, while meadows decreased. However, forested and woodland areas increased and were not significantly affected due to their protected status.
Tessier 2022	Trail width and understory vegetation was measured at different distances from a trail in New York State, USA. Soil compaction was greatest in the trail. Species richness in the understory was highest adjacent to the trail than further away. The plant community beyond the trail was not significantly affected by the trail. As such, the major impact of the trail is the loss of plants as trail width increases. Avoiding this will require hiker education and sustainable trail design.

Ecological Papers continued	Impact of behaviours on woodlands
Summers et al. 2022	Surveys in the Cairngorms, Scotland, show that roads and tracks that are used extensively for recreation are associated with the reduced presence of capercaillie in the nearby area.
Štraus et al. 2023	Soil from forests in Catalonia, Spain, along with vegetation surveys showed that for chestnut and beech forests, incidence of Phytophthora was much higher in areas with high levels of recreation. However, the causal mechanism is unclear.

## Impact of public behaviours on woodland ecological health and quality

The COM-B model (capability, opportunity motivation -> behaviour) and the Behaviour Change Wheel (see Figure 1) have frequently been used to design behaviour change interventions, including by national government (West & Michie 2020).

The Behaviour Change Wheel (West et al. 2020) suggests that effective interventions must be predicated on an understanding of drivers of the original unchanged behaviour, including motivations.

Search terms used to find evidence in this subject area were:

- Visitor AND motivation AND off-trail
- Visitor AND forest AND education AND sign
- 'Leave no trace' AND forest

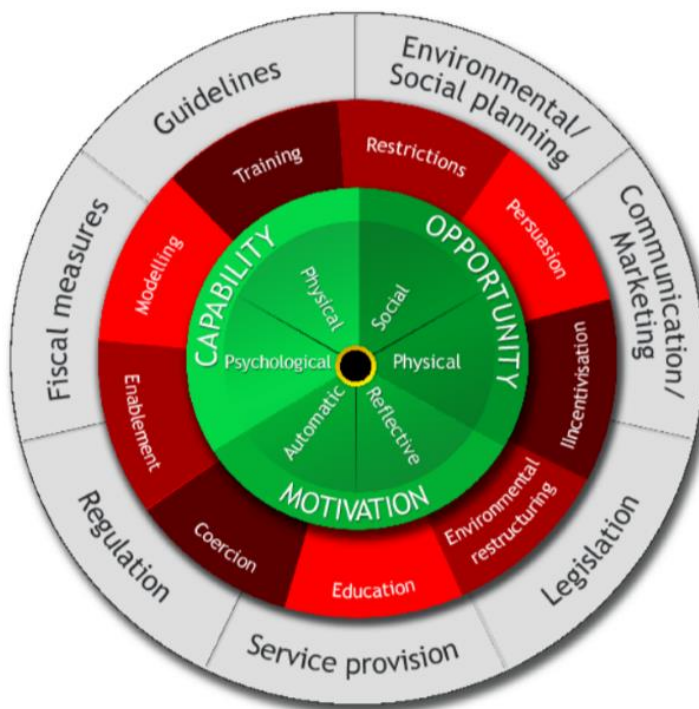


Figure 1 The Behaviour Change Wheel (West et al. 2020). The rings, from the centre outwards show: factors that influence behaviour (green), interventions (red) and policy options (grey).

There is some evidence investigating why visitors to green spaces go off-trail. Goh (2023) used the Theory of Planned Behaviour to explore whether visitors to a National Park would venture off-trail. He was able to predict over 21.7% of behavioural variance and found that the strongest belief was that walking off-trail would result in shorter routes, while the normative influence of friends was also a strong predictor (Goh 2023). A study of US National Park visitors found that their adherence to Leave No Trace (LNT) principles could be predicted by their belief in the effectiveness of LNT and their perception of the difficulty of the related behaviours (Coulson et al. 2021).

Korpilo et al. (2018) explored green space use in Helsinki's Central Park and found that off-trail use was correlated with types of users, for example, runners and cyclists predominately stayed on formal trails while mountain bikers used a limited array of informal paths and walkers (including those with dogs) went off-trail frequently and had a more scattered distribution. The primary motivation behind going off-trail was the positive draw of being in the nature environment, for example, pursuing views of scenery and wildlife (ibid.). They suggested mitigating the impact by encouraging the use of a few existing informal paths that are distant from sensitive or protected areas (ibid.). In line with this recommendation, a study of trekkers in a Slovakian National Park found that most respondents were willing to mitigate going off-trail if they had the opportunity to be educated on the benefits of this for protected areas (Janočková & Jablonská 2013).

Educational interventions are often predicated on the assumption that lack of knowledge is a factor contributing to the behaviour, or that additional information will have a persuasive effect. However, as Goh (2023) shows, there are a variety of other factors driving behaviours such as venturing off-trail. In addition, some educational interventions such as signs, which are frequently used in woodland contexts, have limited evidence of effectiveness and may not effect all user groups equally (Marzano & Dandy 2012.: 28, Backman et al. 2018). Some studies also only measure knowledge acquisition without monitoring if this led to the desired behavioural change (e.g. Wu et al. 2021).

It is also important to consider the crafting of messaging when determining the effectiveness of educational and persuasive interventions such as signs. Winter et al. (2014) used a large-scale survey to investigate the most effective messaging for mitigating damage to recreational sites. They found that respondents found encouragement-based and prescriptive messaging more effective than the opposite, and that this stood in contrast to most relevant signage in recreational areas which tended to focus on discouraging negative behaviours (ibid). Other studies have

suggested that communication should focus on emphasising the positive impact and ease of desired behaviours (Coulson et al. 2021).

Other interventions for mitigating the impact of people in woodlands could be categorised under the Behaviour Change Wheel (West et al. 2020) as environmental restructuring and restriction. In the context of human behaviours in woodlands, environmental restructuring would include creating buffers, including natural barriers and fences (Corney et al. 2008, Littlemore & Barlow 2005), as well as designing paths and facilities to engender the desired outcome. Restrictions are likely to be unpopular but could include limiting access to a sensitive area or during specific ecologically important time periods (i.e. nesting season, at night) (Littlemore & Barlow 2005).

### 3 Conclusions

The research on the impact of human and companion animal behaviours on the health and diversity of woodlands and Ancient Woodlands has predominately focused on disturbance effects. In addition, most of this research has focused on birds, with some papers considering soil, vegetation and some large mammals such as a deer. Most of this literature relates to walking in woodlands, with particular focus on those who go off-trail or use informal paths. There was also an acknowledgement of other damaging human behaviours in the literature (I.e. improper waste disposal, intentional damage, spread of invasive species etc) but this was largely unquantified.

With regards to behaviour change, there is some literature on the motivations behind relevant behaviours, especially with regards to walking off-trail. If it's accepted that successful behaviour change interventions must be designed to meet the determinants of behaviours (West et al. 2020), then further data is needed.

This review has identified evidence gaps, even when considering woodlands generally without specifying Ancient Woodlands. These gaps concern the impact and prevalence of particular behaviours, as well as the determinants of such behaviours and what successful interventions might look like. Given the limited resource of the work package, it is proposed to select case study sites based on a typology of Ancient Woodland development characteristics, with focus groups addressing the prevalence, severity and motivations behind the public behaviours identified as interest, including off-trail activities, dog-walking and garden waste dumping and more.

Data on these areas can be used to propose and potentially design interventions for future testing. It is also worth mentioning that the literature doesn't differentiate between different kinds of Ancient Woodland (e.g. Ancient Semi Natural Woodland, Plantations on Ancient Woodland Sites, Restored Ancient Woodland Sites, Ancient Woodland Site of Unknown Category) or by ecological classification such as the National Vegetation Classification. Besides age and species composition, it is also important to consider habitat sensitivity, geographical context and the history of use or management (Alice Broome, pers. comm, 2023). As such, while this work package will focus on the prevalence of behaviours with likely negative impact, contextual information about each case study site will enable consideration of the severity of impact and potential suitable interventions.

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