Supplementary Appendix: Additional details.

Further details on methods and results not presented in the main text (due to word limits) are provided below.

A1. The current analysis uses two different weights: a) 'weekweight', and b) 'weekVweight'. To explain these weights it helps to recognise that the MENE data is provided across two different datasets, one called the "Respondent based file" and one called the "Visit based file". The Respondent based file uses the individual respondent as its unit of analysis and each row represents a single respondent. The visit based file uses individual visits in the last week as the unit of analysis and thus each row represents a single visit. Where individuals made multiple visits during the last week they will have multiple rows (up to a maximum of 10). The 'weekweight' is included in the Respondent based file and its use here is to essentially provide a 'demographic weight' based on "age, sex, region of residence, social grade, presence of children in the household, working status, presence of a dog in the household and urban/rural residence" (MENE Technical Report 2014-2015, p.16, Natural England 2015). According to the same report "weighting targets used are representative of the English adult population and use the latest data available, updated each year" (p.16). The report also says other demographics have been tested, with no improvement in the outcomes. The 'weekVweight' is used in the Visit based file and uses the "total claimed number of trips" per week, per participant, to help derive estimates of the total number of trips to natural environment per year, across the population. This weight also includes details of the demographic weights and a "correction factor", which takes into account the number of trips stated versus the number of specific trips actually described. Full details can be found in the MENE Technical Report 2014-2015. Of note, there are some small differences in our estimates of the total number of visits and those in the MENE annual reports, e.g. by specific activity type. The main reason for this, we believe, is that our analysis discounts visits where multiple activities were undertaken (because we were unable to attribute duration to each activity), whereas the annual reports include visits with multiple activities.

A2. The duration question in the MENE is somewhat ambiguous: "*How long did this visit last altogether – that is from the time you left to when you returned?*". Although the question implies including travel time (e.g. from home), pre-screening suggests that some respondents may have already subtracted travel time from their estimates. Specifically, once we had subtracted travel time estimates from all visits in the MENE, using the method detailed in [20], approximately 18% of visits had a negative duration. For current purposes, these negative duration visits were simply recorded as <30 minutes and were thus not included in estimates of active visits. More accurate estimates of time spent in natural environments are important in future research.

A3. The MENE does not offer 'gardening' as a possible response option for the activity question because the survey focuses on activities 'away from home'. Nevertheless, one of the locations that respondents could select was 'allotments or community gardens'. Consequently, if respondents had selected 'other' as the activity and 'allotments or community gardens' as the location, we created the novel activity category of 'allotment/gardening' and assigned it 4 METs.[20] Given that there were an estimated 2.5 million allotment/community garden visits, 2 million of which were ≥30 minutes, it was important to try and incorporate this activity into our estimates.

Further, one activity option in the MENE was 'fieldsports (for example, shooting and hunting)'. However, we suspect it was widely misunderstood as many instances of 'fieldsports' were reported by young people and took place in urban parks. We believe they interpreted 'fieldsports' to reflect things like informal games of football in instances where interviewers may not have also read out the bracketed examples. Consequently, if an instance of 'fieldsports' was recorded in an urban setting, we re-allocated it to the category of 'informal games' and only left the activity to reflect hunting/shooting if it occurred in rural areas. In order to establish the MET rate for hunting, we selected the most applicable UK activity ('shooting pheasant and grouse', i.e. 6 METs) from the list of predominantly

American hunting activities (e.g. shooting moose and racoons).[22] We recognise that some misclassification error may remain, but since 'fieldsports' was a relatively infrequent activity we do not believe it would have had a large impact on results.

A4. 'Playgrounds' and 'playing fields' were combined because they were often selected together, featured similar activity profiles, and we wanted to reduce the number of 'multi-location' visits. 'Villages', were added to the 'other' category because we were unsure what kind of natural environment they represented.

A5. Socio-economic groupings, as identified in the MENE survey data, were based on the following categorisations: A/B = high/intermediate managerial, administrative or professional; C1 = supervisory, clerical and junior managerial, administrative or professional; C2 = skilled manual worker; D/E = semi and unskilled manual workers, state pensioners, casual or lowest grade workers, unemployed with state benefits only.

A6. MENE assigns each individual one of 8 rural-urban classifications (based on post-code data) ranging from 'Hamlet Isolated, Dwelling Sparse' to 'Urban >10k Less sparse'. For current purpose we collapsed the two Urban categories of 'Urban >10k sparse' and 'Urban >10k Less sparse' which constituted 80.5% of the sample. The remaining six categories, including hamlets, villages and town fringes, were combined into the rural category constituting 19.5%.

A7. The QALY estimation is based on Beale et al. [17, 21]. As the prior report is more detailed we base our estimates on these calculations. Beale et al. [21] used regression analyses and cost savings through diseases averted to estimate QALY gains from increases in physical activity over a one month period. To do this the authors used data on self-reported physical activity (i.e. number of moderate intensity sessions of physical activity ≥ 30 minutes) and self-assessed health (SAH, i.e. "how is your health in general") from the 2006

Health Survey for England and converted the SAH categorical results, ranging from 'very good' to 'very bad', to cardinal values by assigning health index scores and calculating the critical values that define the intervals. This approach suggested that an extra 30 minutes of moderate intensity activity *per month*, if conducted for all 12 months of a year, would contribute to an average increase of 0.0026692 in the mean health index score. This was then converted into an estimate of the subsequent long-term QALY gain. The authors estimated QALY gains by multiplying the average increase in the health index by the additional sessions of activity over a period of time. For instance, if someone increased their activity by 30 minutes *per week* over a period of 12 months they would benefit from a 0.0106768 (or 0.0026692 x 4) QALY gain for that year. It is these estimates (i.e. ~ 0.010677) that we base our results on here.

Of note, in a comprehensive discussion of potential ways to conduct economic valuation of the 'cultural ecosystems services' associated with natural environments, Mourato et al. (2010) discuss, and present data on, a range of alternative ways for exploring the relationships between exposure to natural environments, including via physical activity, and health. In their final analysis, based on a survey of 1,851 people, they estimate how contact with natural environments, e.g. via a home window view or from regular visits to the countryside, might influence health in terms of QALYs, via responses to the SF36 questionnaire, which measures both physical functioning and emotional wellbeing. Although the results are highly relevant for the overall discussion of natural environments and health, the study did not differentiate between physical activity undertaken in natural vs. indoor/urban settings, and the sample was not as representative of the adult English population as the Health Survey for England[17]. Nonetheless, we recognise both the importance of the work conducted by Mourato et al. (2010), and their conclusion that QALY estimates based on this kind of work, including our own, "are indicative only and subject to many assumptions … and should therefore be treated with caution" (p.77).

A6. The following inputs were used for the robustness check for walking using the HEAT tool. As we were only interested in those who visited natural environments and also met recommended guidelines, the total number of individuals we entered as walking was n = 2,119,667, i.e. the yearly average over the 6 year study period. On the basis that the average number of visits among this group was 3.7 visits per week, we estimated the average walking duration to be a conservative 90 minutes per week (i.e. 3 x 30 minutes). As 93% of this cohort also reported visiting nature at least weekly, we also assumed that this level of 90 minutes of walking per week was maintained by all respondents over the course of the year. Although we recognise that visit quantity may fluctuate over the year, the MENE is careful to conduct data collection throughout the year so in theory this should even out. In addition to providing this estimate of the number of walkers and the average duration per capita, we selected the option for 'a single point in time' rather than a pre-post estimate of change, and estimates of mortality rate based on the 'average population (20-74 yrs)' in the UK. Finally, we also selected the options to include the UK value of a statistical life as £3,229,114, and estimates of benefits for '1 year', 'no cost-benefit analysis' and no discount rate. If a 5% discount rate had been applied, the estimated benefit would have dropped to £1,667,544,000, which was within the 95%CIs for our QALY estimate.

A8. That the data were self-reported raises a number of issues because we assumed that respondents were: a) accurately reporting the duration of self-reported activities; b) engaging in the level of intensity associated with these activities, as set out by Ainsworth et al.,[21] for the entire duration; and c) accurately reporting the frequency of physical exercise over 30 minutes a week. We recognise that if any of these assumptions weren't met the current approach may result in an over- (or under-) estimation of the benefits. In an attempt to mitigate the first two issues, all self-reported visit duration was capped at just 30 minutes, despite many visits being significantly longer (i.e. Mean visit duration = 54 minutes; Median duration = 40 minutes). We believe this reduces both the possibility of over-estimation of visit

duration and intensity duration, because the average visitor (40 minutes) could be effectively stationary for 25% of the time (10 minutes) and still meet the 30 minute threshold for activity.

We are less worried about social desirability effects in the current work than we might otherwise have been, because the questions pertaining to visiting nature did not mention physical activity or health at all, they merely asked for a description of the visit, its length and activities undertaken, which we only subsequently attributed METS to, and the question on physical activity frequency was embedded in a broad range of demographics rather than many questions on health. In support of our suggestion, we compared the current data with that from the Health Survey for England. For instance, the HSE found that in 2012, 43% of men and 32% of women self-reported meeting the guidelines as operationalised using the 5 x 30 minutes a week approach: http://www.hscic.gov.uk/catalogue/PUB16988/obes-phys-acti-diet-eng-2015.pdf. By contrast, only 17.8% of our total sample reported meeting guidelines which is much closer to the levels established using accelerometers in the 2008 HSE sub-sample. Thus although there will inevitably some inaccuracy in our estimates based on self-report data, we suspect it was far less in this sample than the nationally recognised HSE instrument precisely because the focus of the current survey was not on health behaviours. Clearly, however, further research using more objective measures of naturalistic physical activity in different natural environments is needed to help assess the robustness of our assumptions and to provide even more accurate assessments in future work.

References

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