Biological Conservation 214 (2017) 260–269

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

The environmental footprints of conservationists, economists and medics compared

Andrew Balmford[a,*], Lizzy Cole[a], Chris Sandbrook[b,c], Brendan Fisher[d,e]

[a] Conservation Science Group, Dept of Zoology, University of Cambridge, Downing St, Cambridge CB2 3EJ, UK
[b] UN Environment World Conservation Monitoring Centre, 219 Huntingdon Rd, Cambridge CB3 0DL, UK
[c] Dept of Geography, University of Cambridge, Downing Place, Cambridge CB2 3EN, UK
[d] Environmental Program, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT 05405, USA
[e] Gund Institute for Environment, University of Vermont, 617 Main St, Burlington, VT 05405, USA

ARTICLE INFO

Keywords:
Pro-environmental behavior
Flying
Meat consumption
Energy saving
Greenhouse gas emissions
Environmental education

ABSTRACT

Many conservationists undertake environmentally harmful activities in their private lives such as flying and eating meat, while calling for people as a whole to reduce such behaviors. To quantify the extent of our hypocrisy and put our actions into context, we conducted a questionnaire-based survey of 300 conservationists and compared their personal (rather than professional) behavior, across 10 domains, with that of 207 economists and 227 medics. We also explored two related issues: the role of environmental knowledge in promoting pro-environmental behavior, and the extent to which different elements of people's footprint co-vary across behavioral domains. The conservationists we sampled have a slightly lower overall environmental footprint than economists or medics, but this varies across behaviors. Conservationists take fewer personal flights, do more to lower domestic energy use, recycle more, and eat less meat - but don't differ in how they travel to work, and own more pets than do economists or medics. Interestingly, conservationists also score no better than economists on environmental knowledge and knowledge of pro-environmental actions. Overall footprint scores are higher for males, US nationals, economists, and people with higher degrees and larger incomes, but (as has been reported in other studies) are unrelated to environmental knowledge. Last, we found different elements of individuals' footprints are generally not intercorrelated, and show divergent demographic patterns. These findings suggest three conclusions. First, lowering people's footprints may be most effectively achieved via tailored interventions targeting higher-impact behaviors (such as meat consumption, flying and family size). Second, as in health matters, education about environmental issues or pro-environmental actions may have little impact on behavior. Last, while conservationists perform better on certain measures than other groups, we could (and we would argue, must) do far more to reduce our footprint.

1. Introduction

Conservationists fly, sometimes a lot more than our fellow citizens (Fox et al., 2009; Grémillet, 2008). We buy a lot of computers; and some of us – even some marine experts - eat swordfish (Bearzi, 2009). These specific examples highlight a much broader and deeply worrying issue. Conservation is fundamentally about changing people's behavior. As such, conservationists should be in the vanguard – actively (and visibly) adopting pro-environmental behaviors in their personal lives in order to lower our own footprints as much as possible. Failure to do so risks undermining the credibility of the conservation movement. Documenting and understanding our failings, however, might also help identify ways of catalysing and accelerating change across society as a whole.

With this in mind we conducted a wide-ranging questionnaire-based assessment of the environmental footprint of individuals linked to conservation groups (hereafter “conservationists”). Because it is possible that the published examples of conservationists' excess are exceptional and do not generalise, we quantified people's actions across 10 diverse behavioral domains, from recycling to having children, considered to be relevant to environmental impact and over which we suggest individuals have at least some degree of control. Because many other variables impact pro-environmental behaviors – most obviously demographic attributes such as age, gender and income (Alcock et al., 2017; Csutora, 2012; Gatersleben et al., 2002; Gifford and Nilsson, 2014; Jones and Kammen, 2011; Kollmuss and Agyeman, 2002) - we

* Corresponding author.
E-mail address: a.balmford@zoo.cam.ac.uk (A. Balmford).

http://dx.doi.org/10.1016/j.biocon.2017.07.035
Received 13 January 2017; Received in revised form 24 July 2017; Accepted 30 July 2017

also collected information on these variables, and adjusted our assessments of conservationists' footprints to take them into account. And to help put these findings into context, we extended our sample to two groups with broadly similar educational and applied characteristics – those linked to economics and to biomedical groups (hereafter "economists" and "medics" respectively).

Conservationists might be expected to know more about environmental problems and solutions than these other groups, so this comparison also enabled us to explore one of the core notions of environmental education: that enhanced knowledge promotes greater pro-environmental behavior. Despite observed associations between knowledge and actions (Bamberg and Möser, 2007; Hines et al., 1987), the correlational evidence for this intuitive premise is complex. The essentially linear idea that enhanced knowledge promotes greater awareness in turn triggering pro-environmental behavior is no longer accepted (yet as Kollmuss and Agyeman, 2002 point out, still forms the basis of many NGO and government communications campaigns). Instead, it seems many other psychological and societal factors also influence the expression of pro-environmental behaviors - including values (the importance individuals attach to issues; Bolderdijk et al., 2013; Gromet et al., 2013; Li et al., 2016; Reddy et al., 2017); social norms (and the role of consumption in social signalling; Bamberg and Möser, 2007; Csutora, 2012; Jackson, 2004; Kahan et al., 2012; Kollmuss and Agyeman, 2002; Reddy et al., 2017; Steg and Vlek, 2009; Thøgersen, 2014; Vermeir and Verbeke, 2008); structural, cognitive and economic constraints (which may make more sustainable alternatives unavailable; Csutora, 2012; Gifford and Nilsson, 2014; Jackson, 2004; Kennedy et al., 2009; Kollmuss and Agyeman, 2002); individuals' perceptions of their control over outcomes (Bamberg and Möser, 2007; Gifford and Nilsson, 2014; Hines et al., 1987; Kennedy et al., 2009; Kollmuss and Agyeman, 2002); people's ingrained habits (Jackson, 2004; Steg and Vlek, 2009; Thøgersen, 2014); and so-called choice architecture (the way in which alternatives are presented, with easier, more attractive or default options often perpetuating the status quo; Marteau, 2017; Reddy et al., 2017; Sunstein and Reisch, 2014). Experiments offer some scope for isolating the effects of knowledge from these other factors, but where knowledge effects have been identified they often appear specific to particular behaviors and audiences (Abrahamse et al., 2007; Bolderdijk et al., 2013; Gromet et al., 2013; Huffman, 2009; Kahan et al., 2012; Osbaldiston and Schott, 2012). A further problem is the difficulty of teasing-out long-term impacts from experiments – where exposures are typically brief, and prone afterwards to dilution by many confounding effects. Through their jobs and/or interests we expect that the conservationists we sampled have experienced much longer-term exposure to environmental information than have other respondents. We therefore used our comparison of conservationists with other groups to examine associations between such exposure, environmental knowledge and pro-environmental behaviors, adjusting as far as possible for the effects of other factors.

By generating data on many different aspects of peoples' environmental footprints our survey also provides an opportunity to examine a third issue of considerable practical relevance: how far patterns of pro-environmental behavior co-vary across different domains. Are people that are pro-environmental in one aspect of their lives likely to be so in others, and are the predictors of different behaviors similar across domains? Evidence for such co-variation – for what has been termed the "pro-environmental consistency hypothesis" (Alcock et al., 2017) - is so far rather weak (e.g. Alcock et al., 2017; Barr et al., 2010; Kennedy et al., 2015; Painter et al., 1983). To the extent there are congruent patterns, interventions to shift behaviors could perhaps be generalized, but to the extent they are divergent, interventions probably need to be tailored to specific behaviors and groups (Alcock et al., 2017; Kennedy et al., 2015; McKenzie-Mohr et al., 1995; Osbaldiston and Schott, 2012; Painter et al., 1983). We thus used our measures of different pro-environmental actions to look at how far people behave consistently across behavioral domains, and at how far predictors of inter-individual variation show similarities across behaviors.

2. Materials and methods

Between July and October 2015 we surveyed pro-environmental behaviors and their co-variates through an anonymous questionnaire (Appendix A). After piloting the survey iteratively with 36 undergraduate and graduate students at the Universities of Cambridge and Vermont and receiving approval from the University of Cambridge Ethics Review Group we distributed it electronically via conservation, economics and biomedical organisations to targeted newsletters, mailing lists and social media groups. Respondents were self-selected and thus (as in most studies of this nature) were a non-representative sample. We assigned respondents to our three groups simply based on whether they responded to a communication from a conservation, an economics or a biomedical organisation. The questionnaires were accessed and returned to us via SurveyMonkey (SurveyMonkey Inc., n.d.). Background socio-economic questions asked respondents about their gender, age, nationality, occupation, level of education, household income and size and level of charitable donations. We also asked respondents to rank the importance they attach to the environment (relative to education, the economy, healthcare and immigration; for analysis we reversed the ranks, so that 5 = highest importance). We assessed knowledge about the environment by asking six factual questions about human populations, atmospheric change and species extinction; and knowledge about pro-environmental actions from a multiple-response question about how citizens could most effectively lower their carbon footprint.

Our key behavioral questions (Table 1) asked participants about several behaviors known to cause negative or positive environmental impacts: whether they walked, cycled or used public transport to get to work (Ercan et al., 2016); how often they flew (for work or personal reasons, which we analysed separately; Miyoshi and Mason, 2009); energy-saving measures in their homes (Dietz et al., 2009); whether they offset their energy or travel footprint (Gössling et al., 2007); their level of recycling and composting (Hermann et al., 2011); their production of food waste (Garnett, 2011); their consumption of meat or fish (Tilman and Clark, 2014); their use of bottled water (Botto et al., 2011); the number of children they have (or hope to have; Murtaugh and Schlax, 2009); and their ownership of cats and dogs (Ravilious, 2009). We also invited respondents to give reasons for their answers. Whilst the domains we selected do not enable us to carry out a comprehensive environmental footprint, they do give us a broad indication of respondents' relative environmental performance and allow us to investigate correlations between different behaviors.

Using self-reporting to estimate people's footprints means that impacts may be underestimated as a result of social desirability bias (the tendency to give answers that convey a favorable impression; Gatersleben et al., 2002: Kormos and Gifford, 2014). However, here we are interested in a diverse range of behaviors (many of which are not amenable to more direct measurement – Abrahamse et al., 2007), and are focused not on absolute impacts but on differences across individuals; we are therefore relying on the less extreme assumption that any biases are relatively consistent across respondents (but see Discussion). To tackle the related problem that some self-reported pro-environmental behaviors may have little beneficial impact (Bleys et al., 2017; Csutora, 2012; Kennedy et al., 2015) we used the literature and online calculators to estimate the difference in resulting greenhouse gas emissions of the 5th-percentile and 95th-percentile of respondents, when ranked for each behavior in turn (see Table 1; though note that this of course overlooks other components of the environmental footprint of these behaviors).

In total, 734 participants completed the questionnaire – 300 conservationists, 207 economists and 227 medics; 329 respondents were UK nationals, and 132 were US nationals. There were some similarities in the profiles of those sampled in each group (summarised in Table 2) –

Table 1
Summary of surveyed behaviors, how we scored them, and the range in scores and associated emissions reported in our sample.

Behavior	Scoring system	Footprint range			
		5%ile score	95%ile score	Difference (tCO_{2e}/y)[a]	Source and method
Travelling to work	walk or cycle = 0, train or bus = 0.5, car = 1	0	1	2.1	Clear (n.d.) assumes 15 km each way commute in 2 year-old Ford Focus
Flights per year (work and personal recorded separately)	≤ 3h = 1, > 3 h = 2, with return trips counted as two flights	0 (work) 0 (personal)	20 (work) 16.7 (personal)	12 (work) 9.6 (personal)	Atmosfair (n.d.) assumes ≤ 3h flight is London-Berlin, > 3 h flight is London-New York
Energy-saving measures at home[b]	0.25 for each of insulation, changed temperature settings, double-glazing, and solar panels	0	1	6.0	CoolClimate Network (n.d.), Jones and Kammen (2011), United States Environmental Protection Agency (n.d.), WWF-UK. (n.d.)
Offsetting emissions from home energy use or travel[b]	no = 0, partly = 0.5, yes = 1	0	1	2.3	Atmosfair (n.d.) assumes full offsetting of all personal flights of median respondent
recycling (or composting)[b]	approximate % recycled	0	100	0.25	United States Environmental Protection Agency (n.d.) assumes recycle all paper, glass, plastic and metal
Generating food waste	0.2 for throwing out over the past month any of a piece of fruit, a bag of salad, any leftovers, half a loaf of bread, or half a container of milk	0	1	2.2	WWF (n.d.) assumes score of 1 corresponds to > 30% food waste
Consumption of meat or fish	rough number of meat or fish meals per week	0	14	8.4	CoolClimate Network (n.d.), Jones and Kammen (2011)
Use of bottled water	rough number of bottles bought per week	0	6	0.03	ELUA (n.d.)
Number of children	the number people have or hope to have	0	3	570	Murtaugh and Schlax (2009) footprint of all descendants annualised across estimated 50y life as a parent, assuming constant emissions scenario and medium fertility variant
Ownership of cats and dogs	number of cats and dogs owned	0 (cats) 0 (dogs)	2 (cats) 1 (dogs)	4.6	Rushforth and Moreau (2013) assumes cats eat 50 kg feed/y and dogs eat 100 kg/y

[a] Difference estimates are absolute, and very approximate (and so reported to only two significant places).
[b] To ensure higher-footprint behaviors consistently received higher scores, in subsequent analyses we reversed scores for reducing domestic energy use, offsetting, and recycling.

Table 2
Socio-economic profile of our three groups of respondents.

	Conservationists	Economists	Medics
No. of respondents	300	207	227
% Female	63.7	39.6	67.4
Median age	43	40	37
Nationality			
% UK	57.3	33.3	66.5
% US	23.7	23.7	5.3
% Other	19.0	43.0	28.2
Occupation			
% Professionals	58.7	69.1	53.7
% Practitioners	41.7	58.0	19.4
% Researchers	44.7	76.8	53.7
Education			
% PhD	33.3	64.3	40.1
% Masters	37.0	29.0	28.2
% Other	29.7	6.7	31.7
Median household income/person (£/y)	22,500	24,200	25,000
Median % income to charity	5.6	5.6	3.3
Median rank importance of environment	4.31	3.59	3.02

in median age, and income; but also some marked differences – in gender (with a higher proportion of male economists), nationality (fewer British economists, fewer US medics), occupation (fewer medics declared themselves as “practitioners”), education (more economists had PhDs), and charitable giving (medics on average donated a lower proportion of their salary than other groups). Unsurprisingly, conservationists ranked the environment as being more important to them than did economists or medics. As an aside, it is perhaps noteworthy that a year or so before the Brexit referendum and the Trump election 89.1% of all UK respondents and 94.0% of all US respondents listed the environment as more important to them than immigration – making clear that ours is certainly not a representative sample of society as a whole. This is underscored by all of our groups reporting numbers of children substantially below current cohort fertility rates (estimated at 2.0 and 2.3 for the UK and USA, respectively – Myrskylä et al., 2013).

We used a simple scheme (Table 1) to score participants' responses to each behavioral question, but to make subsequent analyses easier to interpret we reversed the scores for those behaviors that reduced people's footprints (lowering domestic energy use; offsetting; recycling). To look at overall behaviors we then generated a combined score, giving equal weight to each behavior (after combining work and personal flights into a single score). As potential predictors of variation in behaviors, we also calculated simple summary scores of respondents' environmental knowledge and knowledge of pro-environmental actions, and treated rank importance of the environment as a measure of its value to them (sensu Gromet et al., 2013). We analysed associations among response and predictor variables in two steps (as in Alcock et al., 2017), first using ANOVAs and correlations to assess simple patterns among knowledge and behaviors before building Generalized Linear Models (GLMs) to identify independent predictors of pro-environmental behaviors. To check the GLM results were reasonably robust despite their relatively limited predictive power, we supplemented our analysis of variation in overall behavior with a model-averaging, information theoretic approach (weighting the coefficient of each predictor by the model weight and summing over all possible models; Burnham and Anderson, 2002).

3. Results

3.1. Do conservationists have a lower footprint than other people?

For some but not all the behaviors we considered, the conservationists we sampled had a smaller footprint than respondents from other groups (Fig. 1). They took fewer personal flights, did more to lower domestic energy use, recycled more, and ate less meat than either economists or medics. They also took fewer work flights and tended to have fewer children than did participating economists; and wasted less food and tended to offset their footprint more than did medics. However, the differences across groups were quite modest compared with the range of values seen across our sample as a whole (Table 1). Moreover, conservationists were similar to both other groups in how they travelled to work and in their use of bottled water, and (perhaps predictably) owned more cats and/or dogs than did economists or medics. The combined footprint scores across all behaviors were lowest for conservationists, then medics, and then economists (Fig. 1), although when work flights were excluded from the calculation (because these, it could be argued, are beyond the control of the participant), the difference between medics and economists disappeared ($F_{2,723} = 15.71$, $P < 0.001$, with conservationist-medic and conservationist-economist differences significant at $P < 0.05$).

In interpreting these patterns it is important to note that the behavioral domains we considered vary enormously in their environmental impact (Table 1, and squares above plots in Fig. 1), with estimated differences in resulting greenhouse gas emissions between those at the 5th and 95th percentiles for a behavior ranging across more than four orders of magnitude. The observed differences in bottled water use and recycling, for example, have almost no impact on overall emissions, while observed variation in domestic energy-saving, in meat-eating, in flying and especially in having children are associated with very substantial differences in people's footprints. Seen through this lens the better performance of conservationists in terms of personal flights, domestic energy-saving, carnivory and number of children is somewhat encouraging.

3.2. How important is knowledge in predicting variation in people's overall footprints?

The conservationists in our sample scored more highly for environmental knowledge than the medics, but not the economists ($F_{2,731} = 11.56$, $P < 0.001$, with conservationist-medic and economist-medic differences significant at $P < 0.05$). Conservationists also had marginally higher scores than medics but not economists for knowledge of pro-environmental actions ($F_{2,731} = 7.18$, $P < 0.001$; conservationists vs medics, $P = 0.07$; economists vs medics, $P = 0.001$). Given that our three groups differed in other ways too (Table 2), to explore the extent to which knowledge predicts variation in footprints we next built a GLM of our respondents' combined footprint scores, and cross-checked the results via model averaging.

The GLM indicated that participants' combined footprint scores were higher for males, US nationals, economists, those with PhDs or (to a lesser extent) Masters degrees, and those with higher incomes (Fig. 2a). Income and being an economist had especially strong effects, as did an interaction term indicating that, for economists but not others, attaching high importance to the environment was associated with a markedly lower footprint (Fig. 2b). Footprint scores were also slightly lower (at $P < 0.1$) for older respondents, and UK nationals. Importantly, controlling for the effects of other terms, there was no association between participants' combined footprint scores and their environmental knowledge, or knowledge of pro-environmental actions.

The overall explanatory power of the GLM was modest (pseudo $r^2 = 0.17$), although reasonable for an analysis of human behavior (see Abelson, 1985). However, our results were broadly similar when we adopted a model-averaging, information-theoretic approach, which combines the results from all possible models (Fig. A1, Appendix B; though note that the interaction term is no longer significant). Re-running the GLM with the combined footprint score modified to exclude work flights led to a weakening of the model (pseudo $r^2 = 0.13$), to the loss of the effects of education, age and to some extent gender, and to conservationists having a lower overall footprint than both medics and

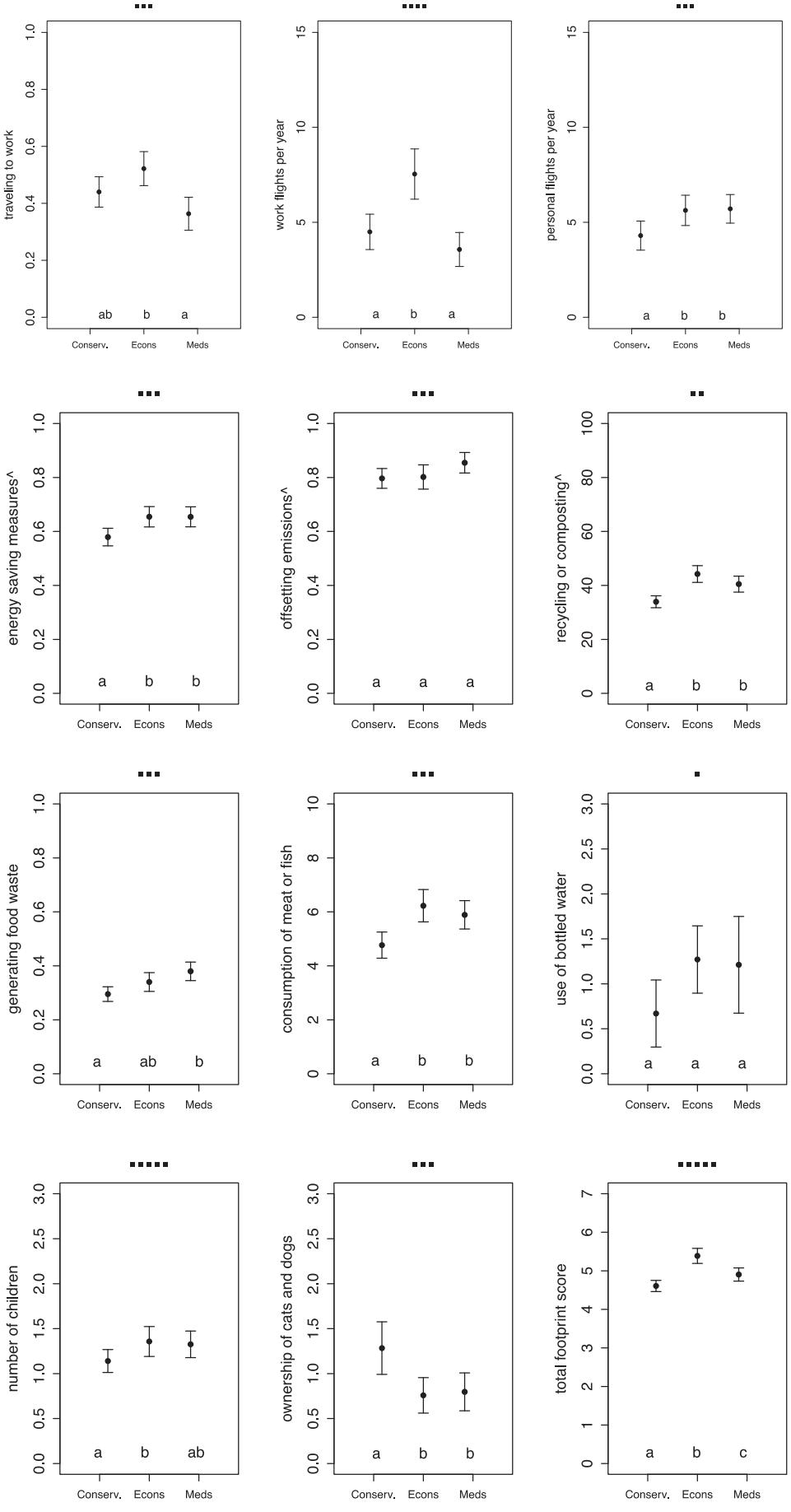

Fig. 1. Footprint scores of conservationists, economists and medics compared, for 11 behaviors, and in total. For more detail on behaviors and how they were scored see Table 1. Plots show means and standard errors, with the range of y-axis values reflecting the span of scores seen in our data (Table 1). ANOVA results: for work travel $F_{2,731} = 6.58$, $P < 0.01$; work flights $F_{2,731} = 13.59$, $P < 0.001$; personal flights $F_{2,731} = 4.29$, $P < 0.05$; energy-saving measures^ $F_{2,731} = 6.23$, $P < 0.01$; offsetting emissions^ $F_{2,731} = 2.46$, $P = 0.09$; recycling or composting^ $F_{2,722} = 14.94$, $P < 0.001$; generating food waste $F_{2,731} = 7.34$, $P < 0.001$; consumption of meat or fish $F_{2,731} = 8.45$, $P < 0.001$; use of bottled water $F_{2,731} = 2.45$, $P = 0.09$; number of children $F_{2,731} = 2.73$, $P = 0.07$; ownerships of cats and dogs $F_{2,731} = 5.48$, $P < 0.01$; total footprint score $F_{2,723} = 20.79$, $P < 0.001$. Occupations that differ significantly in their footprint are shown by different letters. For three behaviors (marked with ^), scores were reversed so that (as with all other variables) higher scores denote a higher footprint. Filled squares above plots indicate the relative environmental impact of observed variation in each behavior, estimated simplistically as the difference in greenhouse gas emissions between those at the 5th and 95th percentiles of our sample for that behavior (■ < 0.1 tCO_{2e}/y; ■■ < 1 tCO_{2e}/y; ■■■ < 10 tCO_{2e}/y; ■■■■ < 100 tCO_{2e}/y; ■■■■■ < 1000 tCO_{2e}/y; Table 1).

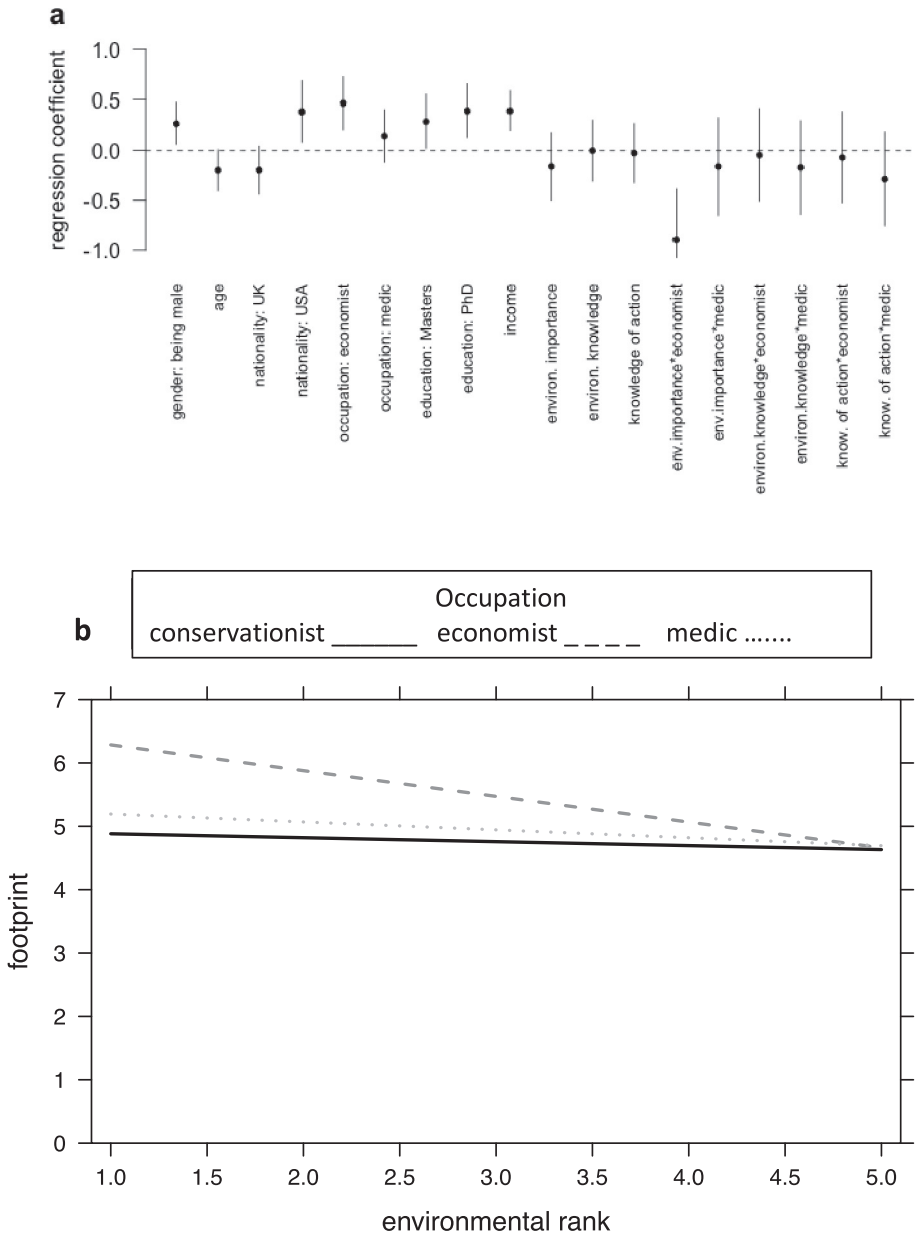

Fig. 2. Results of the GLM predicting variation in participants' combined footprint scores, showing (a) standardised regression coefficients for each term and their plausible two-way interactions; and (b) the interaction between the effect of importance attached to the environment and that of occupation. In (a) bars denote 95% confidence intervals for the coefficient of each term's effect on combined footprint score, relative to that of a female conservationist from outside the UK or US and with no university education. In (b) lines show fitted values.

economists (Fig. A2, Appendix B). Importantly in none of these alternative model formulations was there any association between footprint scores and knowledge of the environment or of pro-environmental actions.

3.3. How far do behaviors co-vary across different domains?

We found only rather limited co-variation across respondents in their scores for different behaviors (Table 3). After adjusting significance values to account for making multiple comparisons, we found that only in a minority of cases did aspects of people's footprints co-vary positively. Individuals who flew more for work also flew more for personal reasons. Those with more pets were more likely to get to work by car. Those who recycled more did more to cut domestic energy use and also used less bottled water, and those who used less bottled water produced less food waste. There were negative associations too: respondents with more children undertook more actions to cut household energy use, those who flew more for work offset their emissions more, and those who flew more for personal reasons had fewer pets. However, all these correlations were relatively weak, and many pairs of behaviors did not co-vary at all.

To explore how far predictors of inter-individual variation differ across behaviors, we built separate GLMs for each behavior in turn (Fig. 3). These had limited predictive power, though each was statistically significant, and together they revealed some interesting patterns. Attaching high value to the environment, for example, was consistently associated with having a lower footprint: through fewer personal flights, more offsetting, less food waste, and less meat consumption. The statistical effect of other predictors, however, varied across behaviors. For instance, respondents with higher incomes had more children and flew more for work and personal reasons, but they also took more steps to cut domestic energy use. Likewise while older participants ate meat more frequently, and had more children and pets, they also made fewer personal flights, undertook more energy-saving measures, recycled more and were more likely to offset their emissions. Higher environmental knowledge and knowledge of pro-environmental actions were both associated with a lower footprint in how people get to work, but showed very limited links to any other behaviors.

Table 3
Spearman rank correlations between the footprints of different behaviors across our 734 respondents. Bold denotes correlations which are significant at $P < 0.05$ after Bonferroni correction for 55 comparisons. Scores for behaviors marked † were reversed (see text). Hence significant positive correlations indicate that individuals with a high footprint for one behavior had a high footprint for the other, while significant negative correlations indicate a high footprint in one domain was associated with a low footprint in the other.

	Work flights	Personal flights	Energy-saving at home†	Offsetting †	Recycling †	Food waste	Meat consumption	Bottled water	No. of children	No. of cats and dogs
Travelling to work	0.01	**−0.12**	**−0.11**	0.00	0.01	**0.13**	**0.13**	0.03	**0.10**	**0.16**
Work flights		**0.26**	**0.14**	**−0.13**	**0.10**	−0.05	0.02	**0.13**	0.03	0.06
Personal flights			**0.16**	**−0.08**	**0.12**	0.04	−0.05	0.02	**−0.12**	**−0.14**
Energy-saving at home†				0.06	**0.26**	−0.01	0.01	0.06	**−0.25**	**−0.13**
Offsetting†					**0.08**	0.04	**0.10**	0.00	0.02	−0.01
Recycling†						**0.15**	**0.15**	**0.14**	**−0.06**	−0.01
Food waste							**0.10**	**0.15**	**0.09**	0.05
Meat consumption								**0.12**	**0.11**	0.04
Bottled water									**0.09**	0.00
No. of children										**0.11**

4. Discussion

Our results suggest the following answers to our main questions:

1. Conservationists have a somewhat lower environmental footprint than economists or medics, but this difference varies across behaviors, is not the case for travelling to work or pet ownership, and is further weakened in GLMs that take into account socio-economic variation across our sampled groups.
2. Variation in people's combined footprint is independently predicted by their gender, nationality, occupation, education, income and the value which they attach to the environment – but not by their environmental knowledge or knowledge of pro-environmental actions. Moreover, both our knowledge measures are no greater among conservationists than economists.
3. Different components of people's environmental footprint are typically not correlated with one another, and show differing demographic patterns - with better paid or older individuals, for instance, having a higher footprint for some behaviors and a lower footprint for others.

These findings are of course subject to several important caveats. First, our respondents were a self-selected and thus non-random subset of the thousands of people who received invitations to participate in the survey. Our assessment of variation in their footprints relies on self-reporting, and therefore on the assumption that the biases this induces are similar across different groups. However, the validity of self-reporting varies (Kormos and Gifford, 2014), and it is possible that conservationists are disproportionately affected by social desirability bias because they know more about pro-environmental actions than (some) others and wish to convey a favorable impression of themselves. To the extent this is true it suggests the behavior differences between conservationists and our other groups are even less marked than we observed. Second, we considered only a fraction of all those behaviors with negative environmental impacts; to make participating relatively easily we measured most of them using fairly crude metrics (e.g. what forms of transport people used, rather than the distances covered); and we combined them without weighting them by their relative impact (though if we had done so, the results would essentially have replicated those for the number of children people have, given the overwhelming impact of this single behavior). Third and most importantly, our results are entirely correlational, greatly limiting our ability to understand the causality of the patterns we observed. Yet despite these caveats, because this is probably the first wide-ranging descriptive survey of the relative footprint of conservationists to date, we believe some cautious inferences can still be made.

Returning to our questions (but in reverse order), across our respondents as a whole there was limited covariation in different aspects of their footprint, with most behaviors we examined predicted by distinct (and sometimes opposing) combinations of socio-economic variables. Other studies have shown similar differences – especially in what predicts variation in different behaviors (e.g. Alcock et al., 2017; Barr et al., 2010; Kennedy et al., 2015; McKenzie-Mohr et al., 1995; Painter et al., 1983) or in the effects of interventions aimed at altering them (Abrahamse et al., 2007; Huffman, 2009; Osbaldiston and Schott, 2012). As one example, in their assessment of people's environmental impacts on holiday, Barr et al. (2010) identified a group of richer, environmentally aware people who (like wealthier individuals in our own sample) take more personal flights than others but are also more likely to offset their emissions, and to adopt energy-saving actions at home. In addition we saw marked variation across behaviors in how conservationists compared with other groups (Fig. 1). We found no difference for the least important and perhaps most trivial behavior (use of bottled water), but somewhat encouraging differences for some more deeply-rooted, higher-impact activities (such as meat-eating, taking personal flights, and having children) – in line, perhaps, with the idea that higher-impact behaviors are harder to shift (Abrahamse et al., 2007). Taken together these results underscore the importance of not assuming that people who are pro-environmental in one domain are necessarily so in others, and support suggestions that different approaches are needed to tackle different aspects of people's footprint (Abrahamse et al., 2007; Alcock et al., 2017; Huffman, 2009; Osbaldiston and Schott, 2012). Our results provide no indication that encouraging relatively easy but low impact behavioral changes (such as increased recycling) is likely to spill over into shifts in other domains, and we instead suggest efforts should focus on devising audience-specific interventions targeting those behaviors with greatest environmental impact. Meat consumption, flying and family size seem like important places to begin.

On our second question, we found almost no evidence that knowledge about the environment or of how to make a difference helps to promote pro-environmental behavior. Neither knowledge variable entered our GLMs predicting combined footprint scores (Fig. 2, Fig. A2), and they contributed to just three of 11 behavior-specific GLMs (Fig. 3), and then only weakly. Moreover, knowledge scores were no different between conservationists and economists (see also Kempton et al., 1995, cited in Kollmuss and Agyeman, 2002). Despite their presumably much more extensive exposure to information, conservationists didn't know much more, and knowledge cannot explain their somewhat lighter footprint. These results mirror those from other environmental studies (Bolderdijk et al., 2013; Csutora, 2012; Gromet et al., 2013; Hines et al., 1987; Jackson, 2004; Kollmuss and Agyeman, 2002; Li et al., 2016; Marteau, 2017; Steg and Vlek, 2009; St John et al., 2013; Sunstein and Reisch, 2014; Thøgersen, 2014; Vermeir and Verbeke, 2008) and from the health sector (e.g. Marteau et al., 2012) which indicate that the effects of income, social norms, habits, infrastructure

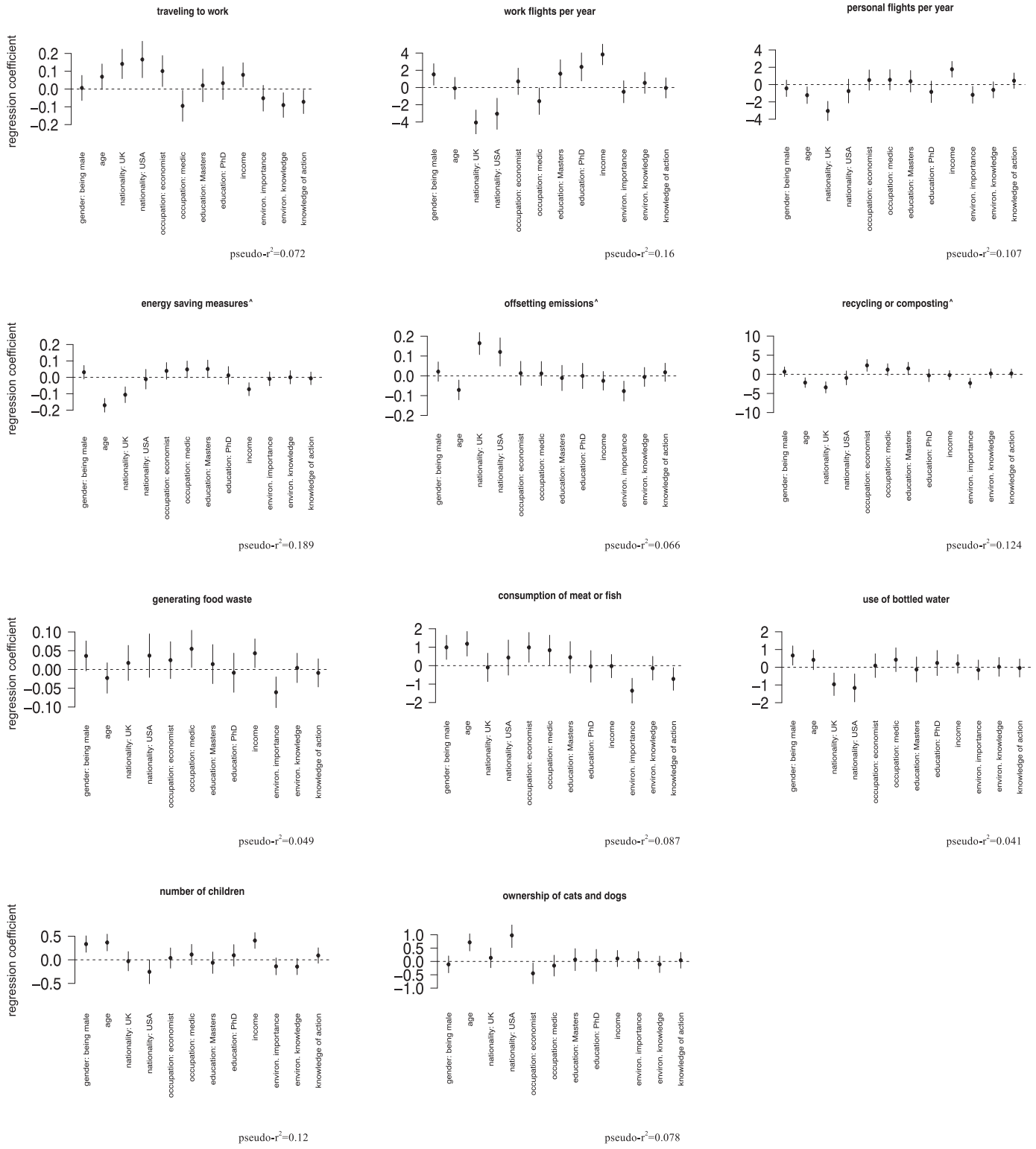

Fig. 3. Results of GLMs predicting variation in participants' footprint scores across 11 behaviors showing standardised regression coefficients for each term. Bars denote 95% confidence intervals for the coefficient of each term's effect on combined footprint score, relative to that of a female conservationist from outside the UK or US and with no university education.

and choice architecture may all be more important than knowledge in shaping our behavior. Indeed there is now growing observational and experimental evidence that among audiences with negative attitudes to the environment, greater knowledge and environmental messaging can even prompt a reduction in pro-environmental behavior (as seen in studies of the effects of pro-environmental product labelling on conservative consumers, and of the Pope's *Laudato Si* encyclical on conservative Catholics - Dietz et al., 2013; Gromet et al., 2013; Kahan et al., 2012; Li et al., 2016). Conservation education may instead have greater impact if it focuses on underlying values (which we found were more consistently linked to behavior than was knowledge; see also Bolderdijk et al., 2013). Improving conservationists' understanding of how to influence values - perhaps through providing formative life experiences (Chawla, 1998) – may be rewarding (but see Manfredo

et al., 2016). Education aside, studies from other sectors strongly suggest that conservationists could profitably do more to tackle structural constraints and choice architecture – both the absence of alternatives to high-impact behaviors, and the subtly counterproductive ways in which, when they are available, such options are often presented (Jackson, 2004; Marteau, 2017; Sunstein and Reisch, 2014; Thøgersen, 2014).

Finally, and closest to home, our results show that – while performing better on certain measures (including some that are high-impact) than do our other groups – as conservationists we could nevertheless do a great deal more to reduce our footprint. We think that trying to lead by example is key to encouraging and sustaining fundamental society-wide changes in behavior. Yet the average conservationist in our sample took three flights each year for work, plus three more for personal reasons; did nothing at all to offset their carbon emissions; and ate meat five times a week – while also listing the environment as their primary concern. As authors, we are every bit as hypocritical. Between the four of us we have seven children, took 31 flights in 2016, and ate an average of two meat meals in the week before submitting this paper. Being the change we wish to see in the world (to misquote Gandhi – Morton, 2011) will require us to make many potentially uncomfortable personal choices - about our family sizes and our diets, for example. But we suggest we must also take active steps as a movement and as a profession (Favaro, 2014). Obvious but challenging starting points could include changing the ways we interact, and measure our performance, so that attending frequent international meetings is no longer regarded as essential to making scientific or personal progress (see also Fraser et al., 2016; and the Flying Less initiative – Flying Less, n.d.); making these and other events we run free from ruminant meat or unsustainably-sourced fish; and offsetting our residual personal and professional footprints (preferably through creating and supporting projects that generate biodiversity co-benefits) rather than continuing to pass on the impacts of our choices to future generations and other species.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.biocon.2017.07.035.

Acknowledgements

We are very grateful to all those who took part in our survey; to the American Economic Association, the Arizona Wilderness Coalition, the Association for Science Education, Bill Bewes at the British Ecological Society, the British Infection Association, Will Simonson of the Cambridge Conservation Forum, Elizabeth Allen at the Cambridge Conservation Initiative, the Medical Research Council, Phoebe Maund, Elena McPhilbin at the Nuffield Department of Medicine (University of Oxford), the Society for Conservation Biology, Siegi Arndt of the UK Network on Environmental Economists, and the University of Cambridge Conservation Research Initiative for distributing the questionnaire; to Andrea Manica and Robin Naidoo for statistical advice; and to Vincent Devictor and an anonymous referee for comments on the MS. This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Abelson, R.P., 1985. A variance explanation paradox: when a little is a lot. Psychol. Bull. 97, 129–133.

Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T., 2007. The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviourbehaviors, and behavioral antecedents. J. Environ. Psychol. 27, 265–276.

Alcock, I., White, M.P., Taylor, T., Coldwekk, D.F., Gribble, M.O., Evans, K.L., Corner, A., Vardoulakis, S., Fleming, L.E., 2017. 'Green' on the ground but not in the air: pro-environmental attitudes are related to household behaviours but not discretionary air travel. Glob. Environ. Chang. 42, 136–147.

Atmosfair. (n.d.). No Title. Atmosfair, Berlin, Germany. (Available from https://www.atmosfair.de/en/ (accessed October 27, 2016)).

Bamberg, S., Möser, G., 2007. Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. J. Environ. Psychol. 27, 14–25.

Barr, S., Shaw, G., Coles, T., Prillwitz, J., 2010. “A holiday is a holiday”: practicing sustainability, home and away. J. Transp. Geogr. 18, 474–481.

Bearzi, G., 2009. When swordfish conservation biologists eat swordfish. Conserv. Biol. 23, 1–2.

Bleys, B., DeFloor, L., Van Ootegem, L., Verhofstadt, E., 2017. The environmental impact of individual behavior: self-assessment versus the ecological footprint. Environ. Behav. http://dx.doi.org/10.1177/0013916517693046.

Bolderdijk, J.W., et al., 2013. Values determine the (in)effectiveness of informational interventions in promoting pro-environmental behavior. PLoS One 8, e83911. http://dx.doi.org/10.1371/journal.pone.0083911.

Botto, S., Niccolucci, V., Rugani, B., Nicolardi, V., Bastianoni, S., Gaggi, C., 2011. Towards lower carbon footprint patterns of consumption: the case of drinking water in Italy. Environ Sci Policy 14, 388–395.

Burnham, K.P., Anderson, D.R., 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. Springer-Verlag, New York.

Chawla, L., 1998. Significant life experiences revisited: A review of research on sources of environmental sensitivity. J. Environ. Educ. 29, 11–21.

Clear. (n.d.). Calculate My Carbon Footprint. Clear, Bourne End, UK. (Available from https://clear-offset.com/offset-my-carbon-footprint.php (accessed October 27, 2016)).

CoolClimate Network. (n.d.). CoolClimate calculator. CoolCliimate Network, Berkeley, USA. (Available from http://coolclimate.berkeley.edu/calculator (accessed October 27, 2016)).

Csutora, M., 2012. One more awareness gap? The behaviour–impact gap problem. J. Consum. Policy 35, 145–163.

Dietz, T., Gardner, G.T., Gilligan, J., Stern, P.C., Vandenbergh, M., 2009. Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. Proc. Natl. Acad. Sci. U. S. A. 106, 18452–18456.

Dietz, T., Leshko, C., McCright, A.M., 2013. Politics shapes individual choices about energy efficiency. Proc. Natl. Acad. Sci. U. S. A. 110, 9191–9192.

ELUA. (n.d.). Bottled Water and Our Environment. Thunder Bay, Canada. Available from http://elua.com/wp-content/uploads/2013/08/Elua-Bottled-Water-and-Our-Environment.pdf (accessed October 11, 2016).

Ercan, T., Onat, N.C., Tatari, O., 2016. Investigating carbon footprint reduction potential of public transportation in the United States: A system dynamics approach. J. Clean. Prod. 133 (12601-276).

Favaro, B., 2014. A carbon code of conduct for science. Science 344, 1461.

Flying Less. (n.d.) Flying less: reducing academia's footprint. Available from https://academicflyingblog.wordpress.com/.

Fox, H.E., et al., 2009. Why do we fly? Ecologists' sins of emission. Front. Ecol. Environ. 7, 294–296.

Fraser, H., Soanes, K., Jones, S.A., Jones, C.S., Malishev, M., 2016. The value of virtual conferencing for ecology and conservation. Conserv. Biol(Available from http://doi.wiley.com/10.1111/cobi.12837).

Garnett, T., 2011. Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? Food Policy 36, S23–S32.

Gatersleben, B., Steg, L., Vlek, C., 2002. Measurement and determinants of environmentally significant consumer behavior. Environ. Behav. 34, 335–362.

Gifford, R., Nilsson, A., 2014. Personal and social factors that influence pro-environmental concern and behaviour: a review. Int. J. Psychol. 49, 141–157.

Gössling, S., Broderick, J., Upham, P., Ceron, J.-P., Dubois, G., Peeters, P., Strasdas, W., 2007. Voluntary carbon offsetting schemes for aviation: efficiency, credibility and sustainable tourism. J. Sustain. Tour. 15, 223–248.

Grémillet, D., 2008. Paradox of flying to meetings to protect the environment. Nature 455, 1175.

Gromet, D.M., Kunreuther, H., Larrick, R.P., 2013. Political ideology affects energy-efficiency attitudes and choices. Proc. Natl. Acad. Sci. U. S. A. 110, 9314–9319.

Hermann, B.G., Debeer, L., De Wilde, B., Blok, K., Patel, M.K., 2011. To compost or not to compost: carbon and energy footprints of biodegradable materials' waste treatment. Polym. Degrad. Stab. 96, 1159–1171.

Hines, J.M., Hungerford, H.R., Tomera, A.N., 1987. Analysis and synthesis of research on responsible environmental behavior: a meta-analysis. J. Environ. Educ. 18, 1–8.

Huffman, W.E., 2009. Does information change behavior? In: Working Paper No.09026. Iowa State University, Department of Economics.

Jackson, T., 2004. Negotiating sustainable consumption: a review of the consumption debate and its policy implications. Energy Environ. 15, 1027–1051.

Jones, C.M., Kammen, D.M., 2011. Quantifying carbon footprint reduction opportunities for U.S. households and communities. Environ. Sci. Technol. 45, 4088–4095.

Kahan, D.M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L.L., Braman, D., Mandel, G., 2012. The polarizing impact of science literacy and numeracy on perceived climate change risks. Nat. Clim. Chang. 2, 732–735.

Kempton, W., Boster, J.S., Hartley, J.A., 1995. Environmental Values in American Culture. MIT Press, Cambridge, MA.

Kennedy, E.H., Beckley, T.M., McFarlane, B.L., Nadeau, S., 2009. Why we don't "walk the talk": understanding the environmental values/behaviour gap in Canada. Hum. Ecol. Rev. 16, 151–160.

Kennedy, E.H., Krahn, H., Krogman, N.T., 2015. Are we counting what counts? A closer look at environmental concern, pro-environmental behaviour, and carbon footprint. Local Environ. 20, 220–236.

Kollmuss, A., Agyeman, J., 2002. Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ. Educ. Res. 8, 239–260.

Kormos, C., Gifford, R., 2014. The validity of self-report measures of proenvironmental

behavior: a meta-analytic review. J. Environ. Psychol. 40, 359–371.
Li, N., Hilgard, J., Scheufele, D.A., Winneg, K.M., Jamieson, K.H., 2016. Cross-pressuring conservative catholics? Effects of Pope Francis' encyclical on the U.S. public opinion on climate change. Clim. Chang(Available from http://link.springer.com/10.1007/s10584-016-1821-z).
Manfredo, M.J., et al., 2016. Why social values cannot be changed for the sake of conservation. Conserv. Biol(Available from http://doi.wiley.com/10.1111/cobi.12855).
Marteau, T.M., 2017. Towards environmentally sustainable human behaviour: targeting non-conscious and conscious processes for effective and acceptable policies. Phil. Trans. R. Soc. A. http://dx.doi.org/10.1098/rsta.2016.0371.
Marteau, T.M., Hollands, G.J., Fletcher, P.C., 2012. Changing human behavior to prevent disease: the importance of targeting automatic processes. Science 337, 1492–1495.
McKenzie-Mohr, D., Nemiroff, L.S., Beers, L., Desmarais, S., 1995. Determinants of responsible environmental behavior. J. Soc. Issues 51, 139–156.
Morton, B., 2011, August 29. Falser words were never spoken. The New York Times. Available from. http://www.nytimes.com/2011/08/30/opinion/falser-words-were-never-spoken.html?_r=0.
Murtaugh, P.A., Schlax, M.G., 2009. Reproduction and the carbon legacies of individuals. Glob. Environ. Chang. 19, 14–20.
Miyoshi, C., Mason, K.J., 2009. The carbon emissions of selected airlines and aircraft types in three geographic markets. J. Air Transp. Manag. 15, 138–147.
Myrskylä, M., Goldstein, J.R., Cheng, Y.A., 2013. New cohort fertility forecasts for the developed world: rises, falls, and reversals. Popul. Dev. Rev. 39, 31–56.
Osbaldiston, R., Schott, J.P., 2012. Environmental sustainability and behavioral science: meta-analysis of proenvironmental behavior experiments. Environ. Behav. 44, 257–299.
Painter, J., Semenik, R., Belk, R., 1983. Is there a generalized energy conservation ethic? A comparison of the determinants of gasoline and home heating energy conservation. J. Econ. Psychol. 3, 317–331.
Ravilious, K., 2009. How green is your pet? New Sci. 2731, 46–47.
Reddy, S.M.W., Montambault, J., Masuda, Y.J., Keenan, E., Butler, W., Fisher, J.R.B., Asah, S.T., Gneezy, A., 2017. Advancing conservation by understanding and influencing human behavior. Conserv. Lett (in press).
Rushforth, R., Moreau, M., 2013. Finding Your Dog's Ecological'Pawprint': A Hybrid EIO-LCA of Dog Food Manufacturing. Center for Earth Systems Engineering and Manufacturing, Arizona State University.
St John, F.A.V., Keane, A.M., Milner-Gulland, E.J., 2013. Effective conservation depends upon understanding human behaviour. In: Macdonald, D.W., Willis, K.J. (Eds.), Key Topics in Conservation Biology 2. John Wiley & Sons, Oxford, pp. 344–361.
Steg, L., Vlek, C., 2009. Encouraging pro-environmental behaviour: an integrative review and research agenda. J. Environ. Psychol. 29, 309–317.
Sunstein, C.R., Reisch, L.A., 2014. Automatically green: behavioral economics and environmental protection. Harv. Environ. Law Rev. 38, 127–158.
SurveyMonkey Inc. (n.d.). SurveyMonkey. SurveyMonkey, Palo Alto, CA, USA. (Available from www.surveymonkey.com (accessed December 2, 2016)).
Thøgersen, J., 2014. Unsustainable consumption: basic causes and implications for policy. Eur. Psychol. 19, 84–95.
Tilman, D., Clark, M., 2014. Global diets link environmental sustainability and human health. Nature 515, 518–522.
United States Environmental Protection Agency. (n.d.). Carbon Footprint Calculator. EPA, Washington, D.C., USA. (Available from https://www3.epa.gov/carbon-footprint-calculator/ (accessed October 27, 2016)).
Vermeir, I., Verbeke, W., 2008. Sustainable food consumption among young adults in Belgium: theory of planned behaviour and the role of confidence and values. Ecol. Econ. 64, 542–553.
WWF-UK. (n.d.). How Big is Your Environmental Footprint? WWF-UK, Woking, UK. (Available from www.footprint.wwf.org.uk (accessed October 27, 2016)).