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Awareness of greater numbers of ecosystem services affects preferences for floodplain management

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ABSTRACT

People's preferences for different habitat management scenarios determine the way that floodplain habitats are managed, and the ecosystem services that they provide. Making people aware of a greater number of ecosystem services may encourage them to design habitat management that better balances the provision of conflicting services. To investigate the impacts of ecosystem service information on people's preferences for floodplain habitat management options, we manipulated the number of ecosystem services that participants knew about, and the level of detail of the information they were provided with. The preferences of participants differed depending on the number of services that were described. Providing people with ecosystem service information had a quantifiable effect on their preferences among different habitat management options, and increased the variability in preferences between people. These findings are consistent with the theory that ecosystem service information should encourage people to consider a wider range of benefits that nature provides, and this in turn may enable habitat management that better balances trade-offs between different services. Simply describing more ecosystem services to people had no effect on their preferences for management options, suggesting that detailed, empirical data on ecosystem services are required to affect decision making.

1. Introduction

Human choices determine the structure and function of many habitats: over 50% of the global land surface has been transformed by human management (Hooke et al., 2012). The choices that people make about habitat management are driven by their desires for the benefits (i.e. ecosystem services) that those habitats can provide. Habitat management decisions can have major implications for ecological quality and human welfare (MA, 2005), and the changes to ecosystems caused by management actions can be irreversible (Groffman et al., 2006). For example, removal of invasive shrubs in parts of the United States is intended to stimulate regrowth of grassland vegetation, but such restoration can be inhibited because the shrubs alter soil resource patterns (Brown et al., 1999). Despite the importance of habitat management decisions in determining ecosystem service provision, the underlying factors that influence these decisions have not been well studied (Cowling, 2014). In particular, it is not clear how people's preferences for management options may differ depending on the information that is available to the person. The objectives of this study were to (1) analyse the impact that information about a greater number of ecosystem services had on people's preferences for hypothetical floodplain management options, and (2) to investigate whether preferences differed when the ecosystem service information was quantitative or qualitative. We investigated these questions through an experimental decision making exercise in which a group of non-experts stated their preferences for habitat management options. The proposed management options remained identical in all treatment groups, but the information that described the outcomes to participants was varied in terms of the number of services that were described, and whether quantitative or qualitative indicators were shown.

Ecosystem services are the benefits that nature provides to people, but different benefits are of greater or lesser interest to different people (Reed, 2008). People's preferences for habitat management scenarios depend on the way that they prioritise the relevant ecosystem services (Kørnøv and Thissen, 2000). To make a decision about their preferred scenario in a given management problem, people analyse their understanding of the effects of different management scenarios on service provision, in relation to their ecosystem service priorities (March, 1978; Hogan, 2002). The information that is available to describe the impacts of manage-

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ment scenarios on ecosystem service provision could therefore be expected to impact people's decisions, as it will impact their understanding of the management outcomes.

There are commonly trade-offs between the provision of different ecosystem services, meaning that it is rarely possible to maximise the provision of one service without reducing the provision of others (Bennett et al., 2009; Rouquette et al., 2011). In the past, many habitat management decisions have been made to prioritise the provision of one ecosystem service (typically food production) at the expense of others (Tallis and Polasky, 2009). In contrast, using an "ecosystem services" approach has been proposed as way of better taking into account the impacts of management on a broader range of services (Tallis and Polasky, 2009). Many ecosystem service studies analyse the effects of management actions on the provision of ecosystem services (e.g. Grêt-Regamey et al., 2008; Rouquette et al., 2011), and such information should make habitat managers aware of a broader range of services, and the trade-offs between their provision (Raudsepp-Hearne et al., 2010). Providing people with an understanding of the relationships between management practices and multiple services could be expected to encourage holistic management strategies that balance the provision of conflicting services (Fish, 2011). Despite considerable research into describing the relationships between ecosystem services and the impacts of habitat management on provision, little is known about the way that the quantity and quality of ecosystem service information that decision makers have can affect their management decisions (Laurans et al., 2013; Laurans and Mermet, 2013). In this study we investigate one component of habitat management decision making: the preferences that individual decision makers have for different management scenarios.

An individual making a decision about habitat management is typically presented (implicitly or explicitly) with multiple options. The individual must then compare options based on their expected outcomes in terms of ecosystem services. It may be possible to logically discount some of the available options (Kørnøv and Thissen, 2000) because, assuming that people act rationally, they should avoid management options which underperform in relation to all ecosystem services (Tversky and Kahneman, 1986). If there are multiple scenarios which cannot be discounted rationally, an individual must decide how best to balance trade-offs between ecosystem services (Craik, 1972; Koontz and Thomas, 2006). This personal decision will be affected by the way that an individual prioritises the various ecosystem services that they are aware of, and their understanding of the effects of different management scenarios on service provision (March, 1978; Hogan, 2002).

The information that is available about the impacts of habitat management scenarios can be expected to impact people's preferences for the different options. Information shapes people's understanding of the relationships between ecosystem services, including their understanding of whether, or how, services trade-off against each other. In the simplest case, where information about the provision of only one ecosystem service is provided under multiple scenarios, there is only one logical choice; the scenario which maximises the provision of the given service. As more ecosystem services are considered and more complex trade-offs become apparent, a person making a decision can discount fewer options through logic, so must prioritise the relevant ecosystem services and weigh up the net values of different combinations (Costanza, 2000; Laurans and Mermet, 2013). The way that an individual chooses to prioritise ecosystem services can be expected to vary considerably between people, as it depends on their personal background and set of beliefs (Kumar and Kumar, 2008). We therefore hypothesise that a group of people's decisions may be more varied when they have information about the impacts of habitat management on a greater number of ecosystem services.

Floodplain systems are a habitat that is of high management interest: in Europe over 90% of the area of lowland floodplain has been modified (Tockner and Stanford, 2002). There are commonly trade-offs between floodplain services (Rouquette et al., 2011), so decisions must be made about which services to manage floodplain habitats for. Floodplains have historically been managed for agriculture and to reduce flood risk in downstream areas (Tockner and Stanford, 2002), despite their potential to provide a broad range of services (Tockner and Stanford, 2002; Posthumus et al., 2010; Rouquette et al., 2011). Several previous studies have proposed ecosystem service frameworks for floodplain management decision making (Morris et al., 2009; Posthumus et al., 2010; Sanon et al., 2012), but the impacts of such ecosystem service information on people's preferences for different management scenarios have not been investigated.

2. Materials and methods

2.1. Overview of the study design

We set up an artificial habitat management problem, in which participants were asked to make a series of decisions about their preferred floodplain management options. Participants were asked to take on the role of a representative of a local community during a consultation on a floodplain management project, and were asked to make a series of choices between pairs of seven management scenarios. The scenarios were hypothetical, but were based on the ecosystem services provided by a real floodplain: the Fishlake wetlands in South Yorkshire in the United Kingdom.

Artificial management problems are commonly used to quantify preferences for ecosystem services, for example using choice experiments (Morey et al., 2002; Birol and Cox, 2007). In contrast to a typical choice experiment, we asked questions about only 7 specific management scenarios, rather than generating a fully factorial set of scenarios. We chose not to present a fully factorial choice experiment for reasons of efficiency; it greatly reduced the number of questions that we needed to ask, thus allowing greater replication. The challenge of obtaining a reasonable sample size was particularly great in the present study because of the need to essentially conduct three preference studies, one for each of the information treatments. Furthermore, a fully factorial choice experiment was not required for the present study because the focus was on measuring what people's preferred management options were, rather than quantifying the underlying utility that the choices revealed.

Individual preferences for habitat management options were quantified by asking people to choose between multiple options. Students and staff (both academic and non-academic) from The University of Sheffield in the United Kingdom were recruited for an online decision making exercise over two periods; once in June and once in September 2013. The factor levels for the survey questions were developed through pilot testing with 30 students to ensure that they varied over a magnitude that was large enough to be considered notable by the participants.

2.2. Case study site

The Fishlake wetlands lie adjacent to the River Don, to the east of Doncaster (Latitude: 53.61, Longitude: −1.00). Historically, the area was drained and disconnected from natural flooding, except at extremely high river flows, but in August 2009 restoration works were carried out, which established greater hydrological connectivity between the river and the floodplain. The English Environment Agency designed the Fishlake restoration project following discussions with local stakeholders, government departments, and non-governmental organisations (Hiley et al., 2008; Richards, 2014).

Indicators of four ecosystem services were considered in this study; the presence of European water voles (*Arvicola amphibius*), the capacity of the floodplain for regulating floods downstream, the species richness of wetland birds, and the herd size of beef cattle. Components of biodiversity are considered to be an ecosystem service because of the cultural value attached to many organisms (Aldred, 1994; Oksanen, 1997), and in this study the presence of water voles, a popular species of high conservation interest in the UK (Strachan et al., 2011), was used as an indicator. The return frequency of a flood event that would cause minor damage to a downstream village was used as an indicator of the flood regulatory service provided by the floodplain (Wharton and Gilvear, 2007). The size of the cattle herd that could be sustained on the floodplain was used as an indicator of the provisioning service of beef production (Morris and Brewin, 2014), and the species richness of wetland birds that were likely to be present was used as an indicator of wildlife recreation (i.e. cultural service), because many wetland birds are of recreational interest (Green and Elmberg, 2014), and visitors to wetland areas are often, at least in part, interested in seeing the birdlife. These service indicators are of particular interest at the Fishlake floodplain because the site has historically been managed to reduce flood risk downstream, is now used for extensive grazing by a local farmer, and is visited by local bird enthusiasts. The owners of the floodplain (The Environment Agency) have a legal obligation to cause no harm to the resident water vole population.

2.3. Management scenario survey design

Seven hypothetical floodplain management scenarios were developed, varying from a floodplain with continuous open water (scenario A), to one that would not flood except under normal seasonal conditions (scenario G). The impact of each scenario on ecosystem service provision was then estimated using knowledge of the relationships between flood frequency and the provision of the flood regulation ecosystem service (Richards, 2014). The seven scenarios were designed to be realistic, but also to fulfil the requirements of the experimental design, for example, none of the ecosystem services were completely synergistic with each other. This was to ensure that providing participants with information about increasing numbers of ecosystem services would make it necessary for them to consider a greater number of trade-offs.

The ecology and habitat preferences of water voles have been studied previously at Fishlake (Richards et al., 2014). Water voles were predicted to be present at three of the four wetter scenarios (B, C and D; Table 1) because the species requires standing water and associated bankside habitats (Strachan et al., 2011). Water voles were not predicted to be present at the wettest scenario (i.e. A) because this was hypothesised as an extensive water body with high connectivity to the river and a dynamic shoreline, which would not provide the steep banks that water voles typically require (Strachan et al., 2011).

Downstream flooding was expected to become linearly less frequent as the scenarios became drier (Table 1), because in drier scenarios it was expected that, on average, less of the floodplain would be filled with water. There would therefore be a greater capacity for water to be removed from the river and into the floodplain during periods of high flow. The frequency of flooding changed over a small range (every 20–26 years) because the regulatory capacity of most individual floodplain wetlands is relatively small; it is the net effect of multiple flood storage areas in a catchment that has a larger impact (Baek et al., 2012). Furthermore, from the perspective of the experimental design, pilot testing indicated that most respondents would always prioritise the flood risk regulation service if the variation between attribute levels was on the decadal range. A flood frequency in the range of 20–26 years is slightly more frequent than would normally be expected in the UK, but the Environment Agency's highest flood risk category includes flood return periods of 30 years (Environment Agency, 2014). Additionally, there was an experimental reason for using a relatively high flood return period; preliminary testing of factor levels found that participants tended to discount more realistic flood frequencies (i.e. 50–100 years, Marsh, 2008).

Wetland bird species richness was assumed to be zero at the driest scenario and to increase linearly up to the second wettest scenario (Table 1) following the predicted increase in wetland habitat diversity. The wettest scenario (A) was hypothesised to provide habitat for considerably more wetland species due to the increased area of water bodies and provision of shoreline habitat suitable for wading birds (Rafe et al., 1985; Traut and Hostetler, 2004).

It was assumed that it would not be economically feasible to graze beef at the floodplain below a certain threshold herd size (in this case 20 cattle), and that beef production would thus only be possible at the driest four scenarios (D, E, F and G; Table 1). The bimodal pattern of herd size over these scenarios (peaking at scenarios E and G; Table 1) is partially an experimental construct, as it was desirable that cattle production was not completely synergistic with flood regulation. It is feasible that the use of different breeds could give rise to this pattern; a more productive breed could be used in scenarios F and G, while a hardier breed would be required in scenarios D and E.

Prior to beginning the decision making exercise, participants were introduced to the site and the management problem. They were also provided with photographs and a brief text overview of a number of ecosystem service indicators. This overview described qualitatively the relevance of each ecosystem service indicator and set it in the context of the Fishlake case study. For example, participants were informed that flooding in the downstream village would typically cause minor damage to building exteriors and outside space, and that some people visit floodplains specifically to enjoy seeing wetland birds; these visitors often value the number of species that they can see. Participants were

Table 1
Factor levels of four attributes for the seven floodplain management scenarios. The floodplain management scenarios form a continuum of increasing hydrological connectivity to the river; scenario A is highly connected to the river (i.e. continuous flow in and out of floodplain waterbodies), while scenario G is not connected to the river (i.e. infrequent wetland flooding).

Scenario	Frequency of flooding in local village (years)	Water vole presence	Number of beef cows present	Wetland bird species richness
A	20	No	0	8
B	21	Yes	0	5
C	22	Yes	0	4
D	23	Yes	20	3
E	24	No	25	2
F	25	No	20	1
G	26	No	35	0

randomly assigned to one of three treatment groups, each of which received different ecosystem service information. Each participant was asked to make a series of choices between pairs of management scenarios, which were represented as text (see Appendices S1–3 in the Supporting Information for example questions). To reduce participant fatigue, each individual answered approximately half of the possible pairwise combinations in each treatment group (either 10 or 11 questions). A formal non-committal option was not included, but participants were able to ignore questions if they desired, providing an informal non-committal option.

In the first treatment group (the low-information treatment) participants were aware of a trade-off between flood risk and providing habitat for water voles (see Table S1 for an example question). The driest management scenario (G) would provide the greatest capacity for removing flood water from the river at extreme levels, thus reducing flood frequency downstream at the local village most effectively (Table 1). On the other hand, the intermediately wet scenarios B, C, and D supported a water vole population, with D being the most balanced of these options because it was superior to scenarios B and C in terms of reducing flood frequency (Table 1).

In the second treatment group (intermediate treatment), participants were informed about a further two ecosystem services; the size of the cattle herd that could be sustained on the floodplain and the species richness of wetland birds that were likely to be present. These two ecosystem services were described in the introductory section of the survey, and participants were informed that some wetland birds require habitats similar to water voles, and that there is a conflict between management for water voles and for cattle. Participants therefore had an approximate understanding of the potential trade-offs between services, but were not informed of the detailed impacts of each management scenario on their provision (see Table S2 for an example question).

In the third treatment group (high-information treatment) participants were given detailed information describing the impacts of each management scenario on all four ecosystem services (see Table S3 for an example question). According to this information, the management scenario that would best reduce flood risk (G) would also support the largest cattle population, but would provide no wetland bird species or water voles. Scenario D would provide habitat for water voles and would perform at an intermediate level for both providing wetland bird species richness and supporting a cattle herd (Table 1). Scenario A was designed to maximise wetland bird species richness, but this choice would not provide habitat suitable for water voles, did not support a cattle herd, and had the highest flood risk. In each treatment group the underlying floodplain management scenarios were therefore the same, but participants were provided with different amounts of information that described them.

Relative preference for each management scenario was measured as the proportion of times that the scenario was chosen, divided by the total number times that it was considered and a choice was made. Therefore, non-decisions in which participants made no choice were excluded from the analysis. Relative preferences for the answers to each question were defined similarly as the proportion of respondents who chose the first option over the second. To investigate whether participants made different choices in the different treatments, we compared the mean difference in relative preference for each of the 21 question answers. Comparisons were made pairwise between each pair of the three treatment groups. The significance of differences in preferences between treatments was assessed pairwise using a bootstrap method whereby the participant responses from the two treatments were pooled and resampled, and the difference in mean preference between the two resampled populations was compared 1000 times. This generated a null distribution for the hypothesis that the choices made under the two treatments were not different (Edgington, 1995). The actual mean difference in preference between the two treatments was then compared to the null distribution to calculate the bootstrap probability that the null hypothesis could be rejected.

To quantify variation in preferences within treatments we analysed the variation in the proportional number of times that each scenario was chosen by participants. We characterised this variation as the evenness (Pielou's J) of the proportional preference for each management scenario (Zar, 2010). If people's preferences for scenarios are not variable, we would expect them to select the same scenarios, and the proportional preference for some scenarios would thus be higher than for others. Preference would therefore be unevenly distributed amongst the available options, and the evenness of the proportional preferences would be low. If people's preferences are more variable then we would expect them to select different options, and the proportional preference would be more even amongst the different options. The evenness of the proportional preference would therefore be high. The significance of differences in variability between treatments was assessed pairwise using a bootstrap method whereby the participant responses from the two treatments were pooled and resampled, and the difference in J between the two resampled populations was compared 1000 times (Edgington, 1995).

To infer the potential priorities that participants placed on different ecosystem services, eight additional questions about the participants' engagement with the services were asked during the survey. Participants were asked to indicate how positively they agreed with two statements about each ecosystem service, using a five-level Likert-type scale (statements are listed in Table S4). Patterns in the correlation matrix of these responses were visualised using principal components analysis. To assess whether there were any significant differences in ecosystem service priorities between the treatment groups, the Bray-Curtis similarities of responses to the priority questions were compared across the three treatment groups using ANOSIM. For the high-information treatment group we also assessed whether the priorities of the participants had an impact on their decisions. We used k-means clustering to identify two groups of participants based on their responses to the priority questions, and, though the sample size was relatively small, compared the preferences of these two groups using the bootstrap method outlined above. All statistical analyses were conducted in the R statistical language (R Core Development Team, 2012), and the vegan package was used to conduct ANOSIM (Oksanen et al., 2012). An alpha level of 0.05 was use to assess significance throughout.

2.4. Limitations of the survey design

The survey presents a highly simplified and hypothetical version of an extremely complex environmental management problem. As such, this study cannot reliably be used to inform the design of the Fishlake wetland. However, informing a particular design is not the purpose of this study. By simplifying a real-world problem, we provide insights into the way that information on ecosystem services, and the level of detail with which the information is presented, can have an impact on people's preferences for environmental management.

The university-based sample population is likely to disproportionately represent educated, middle-class individuals, although the survey was sent to all administrative, support, and maintenance staff, in addition to academic members. As such, the population may be limited in representing the wider UK population, or the population of people who usually make decisions about flood management. Nonetheless, for the purpose of investigating the impacts of information on preferences for environmental management options, such departures from reality are less important. The observed relationships between variation in preferences and the number of ecosystem services that people are aware of should be general across all populations, even if the specific preferences of different populations may vary.

It was necessary to partition the choice questions into two blocks, in order to reduce participant fatigue. This is not ideal, as no one respondent compared the full range of pairwise options. However, the choice questions were assigned to the two blocks randomly, so, assuming that the participants assigned to each block evenly represent the same population, the blocking should not affect the overall patterns in preferences for management options.

3. Results

In total the decision making exercise received 297 respondents who made 3054 preference choices, with responses split almost evenly between the two survey periods. The pattern of participant preferences did not differ noticeably between the two survey periods so they were pooled for further analyses. Response rate was similar between the three treatment groups, but was greatest for the low-information treatment (109 participants, 1134 decisions). The high-information treatment received the second greatest response rate (99 participants, 1003 decisions) and the intermediate treatment received the lowest response rate (89 participants, 917 decisions). The majority of participants (251 of 297) responded to the priority assessment statements.

In the low-information and intermediate treatments, the strongest management preferences were shown for option G, which provided the best option in terms of reducing flood risk, and D, which provided the lowest flood risk of the scenarios which had water voles (Fig. 2a and 2b; Table 1). The least preferred scenarios were A, which had the most frequent flooding and no water voles, and E, which also had no water voles and an intermediate flood return period (Fig. 2a and 2b; Table 1). In the high-information treatment the strongest preference was shown for management scenario B, which performed poorly for beef production and flood risk reduction, but relatively well for bird species richness, and supported water voles (Fig. 2c; Table 1). The least preferred scenario in the high-information treatment group was A, in which the local village flooded most frequently and there were no cattle or water voles present. However, scenario A provided habitat for the greatest number of wetland birds (Fig. 2c; Table 1). Relative preferences for the scenarios differed significantly between the intermediate and high-information treatments (bootstrap $p < 0.001$), and between the low-information and high-information treatments (bootstrap $p < 0.001$). There was no significant difference in preferences between the low-information and intermediate treatment groups (bootstrap $p = 0.73$). Variability in preferences between participants was lowest in the intermediate treatment group ($J = 0.93$), followed by the low-information treatment group ($J = 0.94$). The high-information treatment group showed the most variable preferences ($J = 0.98$). The variability in preferences of the low-information and high-information, and of the intermediate and high-information treatment groups, was significantly different (at the $p < 0.001$ level) using the bootstrap procedure. The variability in preferences of the low-information and intermediate treatments did not differ significantly ($p = 0.8$).

Participants varied in their potential prioritisation of the four ecosystem services; principal component one grouped participants who were potentially biased towards prioritising water vole conservation and bird viewing (Eigenvalue: 1.51, and 28% of variance explained, Fig. 1a), while principal component two split these participants from those who were more likely to prioritise flood regulation and beef production (Eigenvalue: 1.32, and 22% of variance explained, Fig. 1a). The factor loadings for the first and second principal components can be found in Table S5. There was no significant difference in the responses of participants to the priority questions between the three treatment groups (ANOSIM; $n = 251$, $R < 0.001$, $p = 0.463$; Fig. 1b). In the high-information treatment group the responses to the priority questions allowed them to be clustered into two groups. The groups were separated along the axis of principal component 2, indicating a difference between a group which were likely to have preferences for scenarios that performed better for beef farming and flood defence (Group 1, with 38 members; Fig. 3), and a group with a greater interest in wetland bird viewing and water vole conservation (Group 2, with 43 members; Fig. 3). There was no significant difference between the two groups in terms of the participants' question answers (bootstrap $p = 0.1$), but the sample size was lower than in the between-treatments statistical tests (81 participants). The proportionally most preferred scenarios were E for Group 1, and B for Group 2.

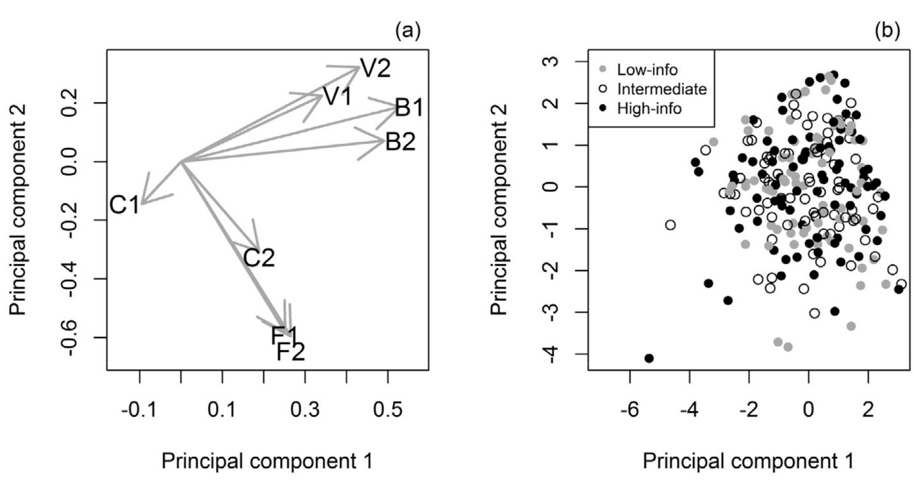

Fig. 1. Principal components analysis of participant responses to preference questions. (a) Loadings of question variables for PC1 and PC2. V1 and V2 are loadings for questions about water voles, B1 and B2 correspond to questions about bird viewing, F1 and F2 are about flood risk, and C1 and C2 are about cattle farming. Loadings which are further from zero indicate stronger, positive responses towards each of the four ecosystem services. See Table S4 for question details. (b) Participants plotted by their PC1 and PC2 scores. Different symbols denote the three treatment groups. Principal component 1 accounted for 28% of the variance; principal component 2 for 22%.

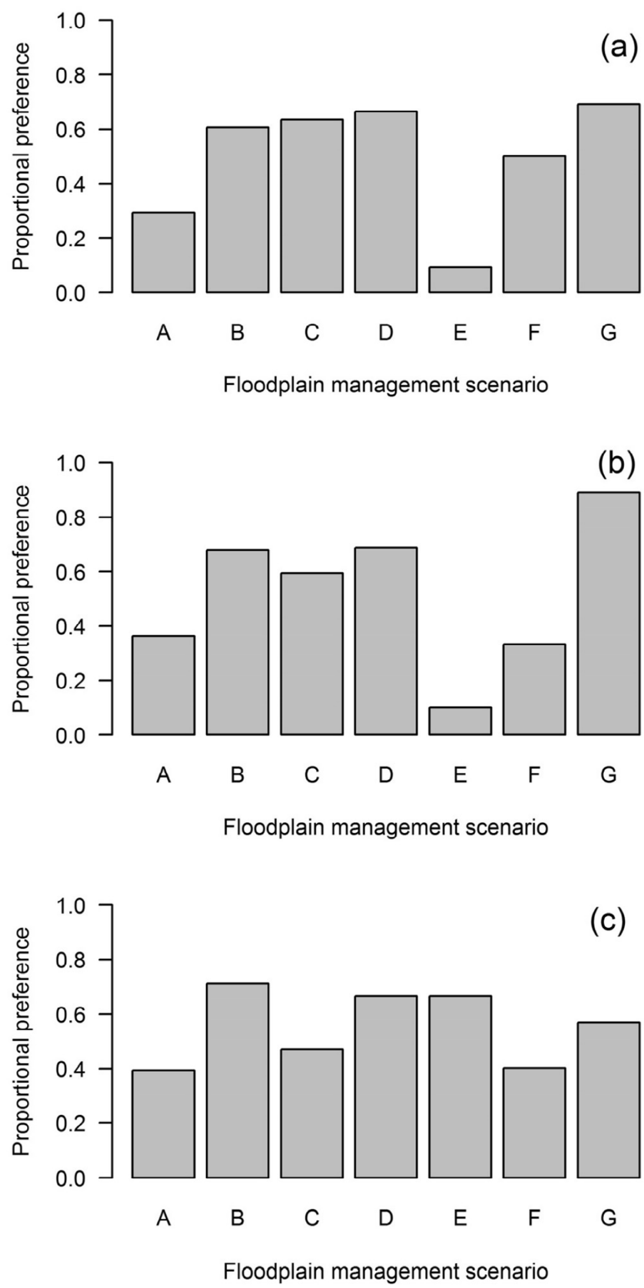

Fig. 2. Proportional preferences for seven floodplain management scenarios (A–G) in three treatment groups. The top panel (a) indicates the low-information treatment, the centre panel (b) indicates the intermediate treatment group, and the bottom panel (c) indicates the high-information treatment group.

4. Discussion

Participants showed significantly different preferences for floodplain management scenarios when provided with the most detailed information on ecosystem service trade-offs. The group of participants who were provided with the most extensive ecosystem service information had the most variable preferences for habitat management options. If these patterns in preferences for management options are present in real-world decision making contexts, there are likely to be implications for the way that floodplains, and other habitats, are managed.

People's preferences for different habitat management scenarios are likely to be affected by their understanding of the ecosystem service outcomes of the available options, and their personal preferences towards particular ecosystem services (March, 1978; Hogan, 2002). In this study there was no significant difference in responses to the preference questions between the treatment groups, so the observed differences in management scenario preferences were most likely due to the different levels of ecosystem service information that participants were provided with. In the low-information and intermediate treatment groups, participants preferred the two scenarios that maximised the provision of the two services that they were informed about (G and D), indicating that they had utilised the available information to identify the trade-off between providing water vole habitat and reducing flood risk.

It is interesting that participants in the low-information and intermediate treatment groups showed no significant difference in preferences or variability of preferences for habitat management options, despite the additional ecosystem services that participants in the intermediate treatment group were aware of. It is possible that the coarse level of detail that was used to describe the additional services in the intermediate treatment may have led participants to consider them as either synergistic (in the case of wetland bird species richness) or conflicting (in the case of cattle herd size) with water vole presence. Participants in the intermediate treatment may therefore have considered the trade-off to be two-dimensional, similar to the trade-off between water voles and flood risk reduction that was presented in the low-information treatment. In contrast, participants in the high-information treatment group were aware of six trade-offs, as all of the four service indicators conflicted to some extent with each of the others. As an alternative explanation, participants in the intermediate group may simply have ignored the services that did not have any detailed information available. It has previously been suggested that qualitative descriptions of ecosystem service impacts may be a cost-effective way to implement ecosystem service frameworks (Busch et al., 2012), but the results of the present study suggest that a detailed knowledge of the ecosystem service impacts of management may be required to make decision makers aware of new trade-offs and make preferences for management options more informed. Selecting and quantifying the relevant ecosystem services for a specific management situation and stakeholder group is therefore an important first step in any attempt to use ecosystem service information to inform management.

Participants in the high-information treatment had the most variable preferences for habitat management scenarios. It is possible that these participants had more variable preferences because the additional information confused them, leading them to select options at random (de Palma et al., 1994). However, this seems unlikely because while the high-information treatment involved more information than the low-information or intermediate treatments, it presented a comparatively simple choice problem. A study of information load found limited evidence of participant confusion with up to 10 options (i.e. management scenarios), or 15 attributes (i.e. ecosystem services) (Malhotra, 1982), although subsequent studies have found that variability in preferences increases with complexity (DeShazo and Fermo, 2002). It is more likely that the additional ecosystem service information presented in the high-information treatment affected people's preferences for habitat management options. The additional information revealed the benefits of the management scenario that appeared suboptimal in the low-information treatment (scenario A), thus making it more attractive and increasing the number of times that it was chosen by participants. Similarly, scenario E was much more preferred under the high-information treatment than in any of the other treatments, probably because the new information revealed that it was the second-best scenario for cow farming, with moderate flood protection and wetland bird provision. Additionally, the broader range of information meant that people had to consider

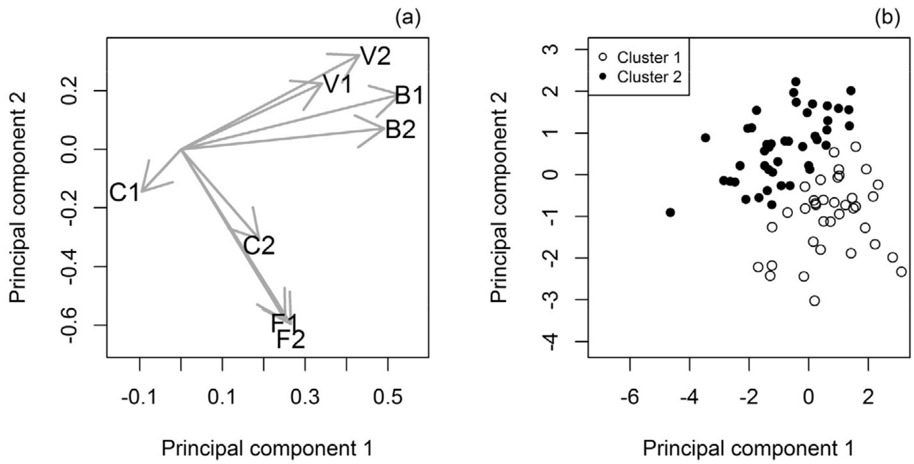

Fig. 3. Clustering of participants from the high information group into two groups, displayed on the same principal component axes that are displayed in Fig. 1a. Principal component 1 accounted for 28% of the variance; principal component 2 for 22%. (a) Loadings of question variables for PC1 and PC2. V1 and V2 are loadings for questions about water vole preference, B1 and B2 correspond to questions about bird viewing, F1 and F2 are about flood risk, and C1 and C2 are about cattle farming. Loadings that are further from zero indicate stronger, positive responses towards each of the four ecosystem service indicators. This Figure is identical to Fig. 1a. (b) Participants from the high-information treatment group plotted by their PC1 and PC2 scores. Different colour symbols denote the two cluster groupings.

a larger number of their personal preferences when making decisions; the decision problem was therefore more complex.

The preferences that people in the high-information treatment group had for the four ecosystem services did not have a significant impact on their preferences, although the sample size for this test was relatively small compared to the between-treatments comparisons (~40 participants in each group) and the inherent variability in preferences between participants was high. The probability that the two ecosystem service preference groups showed different preferences was 0.1, which is indicative of a slight difference in preference between the bias groups, and would be considered significant in many social science studies (Yang, 2010). Participants who were associated with wetland birds and water voles preferred scenario B, which balanced the trade-off between maximising wetland bird species richness and ensuring water vole presence, but performed poorly for the other two services. Participants who had associations with cattle farming or a personal interest in flood defence were more likely to prefer scenario E, which gave an intermediate level of flood risk and the second-highest cow herd size. Despite their interests in farming and flood defence, these participants may have had some sympathy for wetland bird conservation, as scenario E (with two bird species) was preferred over scenario G (with 0 bird species), despite the fact that the latter scenario performed best for both beef production and flood risk reduction.

In this study, people who were presented with information about a greater number of ecosystem services showed more variable preferences for the management scenarios. In some ways this is not surprising, as the new information opened up a wider range of "logical" choices; there were no longer only two options that maximised the provision of a service, but a range of ways in which the trade-offs between the four services could be balanced. However, this finding contributes usefully to the emerging literature on the impacts of ecosystem service information on decision making in three ways. First, our study confirms that people act logically in showing preferences for environmental management scenarios. Second, the greater variation in preferences observed when participants had information on a greater number of ecosystem services was not random, as would be expected if the participants were confused by the greater complexity of the problem. Instead, the management scenario preferences were related to the ecosystem service preferences of the participants, indicating that the information allowed them to act on their desired ecosystem service outcomes. Third, preferences were not altered when people were provided with uncertain information (intermediate treatment), indicating that it is critical to provide real data on the expected impacts of management scenarios.

The results of this study indicate that individual preferences for management options can be affected by the quantity of ecosystem service information available. This provides rare empirical evidence that the breadth of information provided by ecosystem service research can influence decision making, albeit at the level of individuals only. Many European floodplains are managed in a top-down manner by institutions that seek stakeholder participation, partly because river modification and flood defence is expensive to construct and maintain (Barraqué, 2014). Increasing the number of ecosystem services that are analysed during floodplain management decision making should encourage management decisions that are better informed about the trade-offs between services, and a number of frameworks have been proposed for collecting and summarising these data (Maltby, 2009; Posthumus et al., 2010; Sanon et al., 2012). However, people's preferences for management options depend not only on the information that they have, but also on their personal preferences towards specific ecosystem services. In the present study, treatment groups were made up of individuals with different preferences for ecosystem services, so preferences for management options were varied. When a group of decision-makers share similar ecosystem service preferences they are likely to prefer similar management options, as was observed in the preference split between the two ecosystem service preference groups in the high-information treatment. A group of stakeholders are likely to share similar ecosystem service interests. It is therefore important that floodplain managers consult as wide a range of stakeholder interest groups as possible, to ensure that a wide range of ecosystem service preferences are represented in the decision making process (Reed et al., 2009).

Here we have shown that ecosystem service information can impact people's preferences for floodplain habitat management scenarios. However, this simplistic treatment of environmental decision making is far removed from being practically applied to a specific decision-making problem. It would be valuable to develop the approach presented here to evaluate more complex decision making problems. The relationships between people's preferences for ecosystem services and their preferences for management scenarios deserves more attention, and the method applied in this study to analyse this could be improved. The questions used here to evaluate potential preferences towards the ecosystem services were quite abstract, and it may be more effective to ask directly about how participants prioritise the relevant services. When understanding the process through which individuals select preferred management options, people's preferences may also be affected by uncertainty in the outcomes of different options (Simon, 1952), and the likely stability of the resulting ecosystem (Hogan, 2002). Furthermore, the interaction between decision makers within an organisation or group of stakeholders will determine the way that individual preferences are translated into management action. Decision making at higher levels must therefore be monitored and analysed (Koontz and Thomas, 2006). Processes of choice and decision making have previously been studied (Simon, 1952; Bakus et al., 1982; March, 1978; Tonn et al., 2000), but there are few case studies that are directly relevant to habitat management (Koontz and Thomas, 2006; Naidoo et al., 2009; Ruckelshaus et al., 2013). Studies of small group dynamics during decision making problems, such as those used in psychology (Gruenfeld et al., 1996; Kelly and Karau, 1999) and invasive species decision making (Hogan, 2002), could help to improve our understanding of the impacts of ecosystem service information on floodplain habitat management.

5. Conclusions

Providing people with ecosystem service information had a quantifiable effect on their preferences among different habitat management options, and increased the variability in preferences between people. These findings are consistent with the theory that ecosystem service information should encourage people to consider a wider range of benefits that nature provides, and this in turn may enable habitat management that better balances trade-offs between different services. Simply describing more ecosystem services to people had no effect on their preferences for management options, suggesting that detailed, empirical data on ecosystem services are required to affect decision making.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ecoser.2017.02.001.

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