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The economic value of tourism and recreation across a large protected area network

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ABSTRACT

Environmental economists routinely use travel cost methods to value recreational services from protected areas, but a number of limitations remain. First, most travel cost studies focus on a single protected area or a small handful of protected area sites; value estimates that relate to a protected area network across a larger geographic area or jurisdiction are rare. Second, most protected area travel cost studies use on-site sampling techniques that bias value estimates towards those reported by frequent visitors. Values derived from such studies are unlikely to be representative of those held by the broader community, and as such they are of limited utility for strategic land-use planning. We have overcome these limitations to estimate the total value of tourism and recreation for a network of 728 protected areas across 800,000 km^2 in New South Wales (NSW) in south-eastern Australia. This is one of the largest studies of its kind undertaken to date, drawing on data from a stratified random phone-survey of more than 62,000 individuals in which interviewers collected detailed information on the number of visits to any and all of the 728 protected areas within NSW. Our study provides new insights into protected area visitation through the use of a random effects ordered logit model, which allows explicit examination of the distribution of recreational value amongst households. Our modelling estimates the value of tourism and recreation services provided by the NSW protected area network at $AUD 3.3 billion per annum. Most of this value accrues to frequent users from within NSW, particularly those from regional areas. The comparative values presented in our study indicate that the recreational services provided by protected areas and other sites can be a similar order of magnitude to, and perhaps even greater than, the extractive uses that are traditionally assigned economic values. It follows that land-use decisions that fail to account for these values are unlikely to optimise societal benefits from land-use allocation.

1. Introduction

Protected areas provide a broad range of ecosystem services to the human population, including carbon sequestration, water filtration, and cultural and recreational services (Balmford et al., 2002; Chan et al., 2006; Dudley and Stolton, 2010; Palomo et al., 2013). The importance that society places on protected areas and the services they provide is evidenced through broad-based international commitment to developing and maintaining protected area networks in line with the Convention on Biological Diversity (1992) and Millennium Development Goals (2000), and through ongoing government investment in both new and existing protected areas: protected areas now cover 14.8% of global lands (World Databank, 2014).

There is an increasing body of scientific and economic research using and supporting ecosystem service valuation (Loomis et al., 2000; Howarth and Farber, 2002; Armsworth et al., 2007; Barbier et al., 2011). Policy imperatives to value ecosystem services in monetary terms include the International Union for Conservation of Nature (IUCN)'s call for more innovative valuation approaches to support a mandate for conservation (Phillips, 1998) and the System of Environmental-Economic Accounting (SEEA) that is administered and championed by the United Nations (United Nations, 2016). While the move towards monetary valuation of ecosystem services is not without its critics (McCauley, 2006; Silvertown, 2015), it is clear that the lack of a robust estimate of economic value puts protected areas and other natural ecosystems at a disadvantage when resource allocation decisions are made on the basis of economic criteria - as they so often are. In decisions about land allocation, protected areas must compete with

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alternate land-uses like agriculture, forestry and urban development, all of which have economic values that are easily and routinely reported. In these situations, a reliance on economic criteria is likely to yield decisions that maximise private industry gains at the expense of the broader societal values offered by protected areas.

In many ways, valuing recreational services from protected areas is less controversial than valuing other types of ecosystem services. Environmental economists routinely use travel cost methods to quantify the tourism and recreational value of protected areas and other environmental assets. Indeed the travel cost method was first proposed by Hotelling in 1947 for the purpose of protected area valuation (Nillesen et al., 2005; Heberling and Templeton, 2009). Hotelling proposed that a proxy price could be generated from the maximum travel cost incurred by any individual who travelled to a specific national park and subsequently used to compute the consumer surplus enjoyed by visitors who incurred lesser travel costs (as reported in Arrow and Lehmann, 2006). In the past 25 years, travel cost methods have been used to estimate the recreation and tourism value of more than 50 marine or terrestrial protected areas in at least 25 countries around the globe (Web of Science 2016). The results of these studies have been used to justify government expenditure on protected area management (Beal, 1995; Gurluk and Rehber, 2008; Saraj et al., 2009), to provide new insights into visitor demographics or preferences (Font, 2000; Kim et al., 2010; Benson et al., 2013), and to estimate the likely impact of new or altered site entry fees (Nillesen et al., 2005; Becker, 2009; Pascoe et al., 2014).

Despite the popularity and relative maturity of travel cost methods for valuing tourism and recreation in protected areas, a number of limitations remain. First, most travel cost studies undertaken to date have focused on a single protected area, or a small handful of protected area sites; studies that report aggregate values for a whole protected area network are rare (Bujosa Bestard and Font, 2010). Given that research is more commonly undertaken at the most popular or highest profile parks within a network (Kerkvliet and Nowell, 1999, Englin et al. 2006, Gurluk and Rehber, 2008; Benson et al., 2013), and the complexities around issues of scale when aggregating site specific travel cost values (Martin-Lopez et al., 2009; Bujosa Bestard and Font, 2010), it is unclear if or how the results of such studies can be generalised to the broader network scale. This means that the value of protected areas is usually reported in a limited or piece-meal way, and the total tourism and recreation value of the protected area network remains unknown. This short-coming undermines capacity to use the results of travel cost studies to guide or justify management expenditure at the broader agency- or jurisdictional level, or to balance trade-offs with alternative land-uses like agriculture or forestry, where total-value-of-industry figures are readily and routinely calculated and reported.

Second, most travel cost studies, including one that has used meta-regression analysis to estimate total recreational value of the U.S. protected area network (Neher et al., 2013), use on-site sampling techniques. On-site sampling is widely recognised to generate an avidity bias - whereby frequent-users are likely to be oversampled (Bujosa Bestard and Font, 2010; Hindsley et al., 2011). Many travel cost studies seek to address avidity bias by applying the 'Englin correction' - i.e. by subtracting one visit from each respondent's reported number of visits to a site prior to statistical analysis to provide a more realistic estimate of site visitation rates that better reflect those of the broader population (Englin and Shonkwiler, 1995). But Blaine et al. (2015) demonstrate that it provides variable outcomes depending on the underlying model used. Moreover, the Englin correction addresses only one component of avidity bias, i.e. the over-estimation of visitation rates. It does not address a second, and more troubling, aspect of avidity bias, whereby frequent visitors may share a set of common values or site preferences that differ to those of non-visitors or less frequent visitors, leading to skewed model parameters relating to park or demographic attributes. This can introduce additional sources of error when scaling value estimates up from a per trip to a population basis, or from individual sites to an entire protected area network. Given the potential for serious bias arising from on-site surveys, it is unlikely that the values derived from such studies are representative of the values of 'typical' or 'average' park visitors, much less those held by the broader community. Moreover, value estimates from on-site surveys cannot be scaled up to provide a total value of tourism and recreation without robust data on total visitor numbers. Such data are usually absent.

Our study is one of the first to use travel cost methods to estimate the recreational value of a protected area network in its entirety. We have overcome the limitations described above to estimate the total value of tourism and recreation for a network of 728 protected areas across 800,000 km^2 in south-eastern Australia. This is consistent with advice from Bujosa Bestard and Font (2010), who recommend simultaneous valuation of all alternate sites within a jurisdiction as the only satisfactory approach for addressing complexities inherent in aggregate or network valuation studies. We also avoid bias arising from on-site sampling by using data from a stratified random phone-survey of more than 62,000 individuals in which interviewers collected detailed information on the number of visits to any and all protected areas within the state of New South Wales.

Our study provides new insights into the distribution of benefits from protected area visitation through the use of a random effects ordered logit model. This type of model allows explicit examination of the distribution of recreational value across the population, including the degree to which benefits might be concentrated on a small number of avid users, or shared more broadly across the population base. The outcomes of this distributional analysis have wide ranging relevance to protected areas research, management and policy, but to our knowledge, it has never been examined through a large-scale empirical survey.

2. Methods

2.1. Study site

New South Wales (NSW) covers an area of 800,000 km^2, roughly 10% of Australia's landmass, in the south-east of the continent. The NSW protected area network includes more than 860 national parks and reserves, totalling ˜70,000 km^2 in area and covering roughly 9% of the state. For the purposes of this analysis we have amalgamated adjacent parks and reserves that have very similar names. Our final dataset included visitation and travel cost data for 728 protected area sites.

2.2. Park visitation data

This analysis relied on detailed information gained from a primary phone survey of more than 62,000 individuals commissioned by the NSW Office of Environment and Heritage (OEH) and conducted by Roy Morgan Research. Roy Morgan conducted telephone interviews with ˜16,000 individuals from NSW and selected adjoining states (Queensland, Victoria and the Australian Capital Territory) every two years from 2008 to 2014. In total, 62,337 survey respondents were questioned about their recent use of the NSW protected area network, including which sites they had visited, and how often they had visited those sites, in the preceding 4 week period. Where respondents reported visiting multiple sites in the preceding 4 week period, they were asked to provide information for up to 5 protected area sites. Asking respondents to report visitation over longer periods (even a single season) may lead to a situation where respondents find it difficult to recall every trip or provide accurate estimates of the number of trips taken (Bockstael et al., 1990; Parsons, 2003). However, Champ and Bishop (1996) report that with a smaller time lag between a recreational trip and subsequent survey, respondents can provide accurate information - even relating to trip expenditures. Parsons (2003) recommends sampling at intervals throughout the year and asking about trips made over a shorter preceding time period (he recommends one month). Our survey strategy, sampling every 4 weeks throughout the year and restricting questioning to a relatively short (4 week) time period, is consistent with this advice.

The Roy Morgan survey also collected selected demographic information for each respondent, including age, sex, and number of children in the household. Respondent interviews were staged throughout the year, with ˜1200 interviews conducted every 4 weeks from January through to December. This ensured seasonal variation in tourism and recreation activity were adequately accounted for. The survey was also stratified by postcode, with respondents randomly selected from every postcode across the three surveyed states.

2.3. Driving costs and other out-of-pocket expenses

Travel costs were estimated based on the most direct route from the respondent's postcode to the protected area(s) they reported visiting, as calculated using the Google Maps application programming interface. These automated online techniques are increasingly being used to calculate individual travel time and cost parameters in travel cost studies (Englin et al., 2006; Chae et al., 2012; Benson et al., 2013; Conradie and Garcia, 2013; Cho et al., 2014).

In assigning travel costs it was necessary to distinguish between single- and multi-purpose trips. We followed a two-stage procedure. First, we employed a threshold travel time of 4 h (round trip), below which we assume respondents make a single-purpose day-trip visit. Trips above this travel time threshold were considered to be overnight trips. Similar travel threshold techniques have been used by Englin et al. (2006) and Anderson (2010). Next we relied on trip-attribution data from the 2016 Roy Morgan survey in which 65% of respondents reported that visiting a national park was the only or primary purpose of their trip. As we have no way of determining which specific trips within our larger dataset were single- or multi-purpose trips, we have accounted for multi-purpose trips by including only 65% of total travel cost from each trip in our travel cost estimates. This approach avoids problems that can arise when attribution factors are applied to individual trips - whereby respondents who travel from further away but report multi-destination trips might be attributed a lower travel cost than those who have travelled a shorter distance to the site of interest (Beal, 1995) - without inflating estimates of consumer surplus derived from our analysis (Kuosmanen et al., 2004).

Driving costs were estimated based on average vehicle fuel consumption rates for passenger vehicles published by the Australian Bureau of Statistics (2015a) (13.3 litres per 100 km) and average fuel price data published by the Australian Institute of Petroleum (2016). Some researchers use a higher per km estimate based on full running costs, which account for marginal wear and tear on the vehicle (Chae et al., 2012; Benson et al., 2013; Conradie and Garcia, 2013) and / or incorporate a share of annual car maintenance, insurance and / or depreciation costs (Fleming and Cook, 2008; Cho et al., 2014). However, these types of driving-related costs are "less obvious" (Blaine et al., 2015), and moreover, many, like insurance and registration, are fixed costs that will not vary if respondents take additional recreational trips. We consider it unlikely that these types of costs would feature heavily in respondents' decision-making processes in the same way that fuel or other out-of-pocket expenses might, so we have included only a partial value in our analysis.

For overnight trips we have included the cost of overnight accommodation, estimated at $168.27 per night from the Australian Bureau of Statistics (2015b) multiplied by 3.8 nights - the average length of stay as reported from the *National Visitor Survey* (Tourism Research Australia, 2014). As 45% of respondents in that survey report that they stayed with family or friends while travelling, we reduce this overnight expenditure to 45% of the total. We also assume that surveyed respondents travel with one other adult (sharing fuels and accommodation costs) on 50% of all trips, and further reduce total fuel and accommodation costs accordingly. Food costs were not included in our travel cost calculations because these were not considered to be a marginal cost associated with travelling. We acknowledge that people are likely to spend more on food while they are travelling compared to when they are at home, but we considered this to be a relatively minor factor influencing tourists' decisions about travel.

2.4. Opportunity cost of time

We have included the opportunity cost of time using the minimum hourly wage rate for NSW of $16.87 per hour (Australian Fair Work Commission, 2013) noting that this represents 38.7% of the average wage rate of $43.63 for the state. This is a conservative estimate of the opportunity cost of travel time relative to the 75% of wage rate recommended by Fezzi et al. (2014), but it falls between the most common 33% -of wage adjustment used in most travel cost studies (Amoako-Tuffour and Martinez-Espineira, 2012; Fezzi et al., 2014) and the 39.7% -of wage adjustment proposed by Englin and Shonkwiler (1995). We report time costs only for time spent travelling (excluding time spent on-site) following Amoako-Tuffour and Martinez-Espineira (2012). This makes our estimate of the opportunity cost of time a relatively conservative one. We also note that this approach means that no value has been assigned to children's visits to protected areas.

We recognise that it is preferable to include respondent-specific data relating to income and the degree to which individual respondents can trade labour time for recreation to determine the opportunity cost of travel time (e.g. Larson and Lew, 2014), but these data were not available from our dataset. This is a problem that is common to a number of travel cost analyses that rely on pre-existing data from license databases or similar sources (Englin et al., 2006; Heberling and Templeton, 2009; Neher et al., 2013) and we do not consider it to be a major limitation for a number of reasons. First a large proportion of travel cost studies find no significant effect of income (Blaine 2015 cites 9 such studies). Second, an increasing number of travel cost studies now infer income from a respondent's home postcode rather than collecting income data for each respondent (Heberling and Templeton, 2009; Blaine et al., 2015). Third, a range of endogenous factors - including both demographic and personal factors - have the potential to influence the way different individuals might value travel 'costs', including employment status (Blaine et al., 2015), the degree to which a responded derives utility from the drive itself (Hanink and White, 1999), and marginal cost of travel compared to recreational alternatives or other household expenses (Beal, 1995). Accordingly, we have included selected demographic variables *respondents' home region* to capture broad spatial scale variation in income levels and *household size* to represent household expenses. A similar approach has been taken by Amoako-Tuffour and Martinez-Espineira (2012); Loomis and Ng (2012) and Cho et al. (2014). We also include the 4 variables that comprise the Socio-Economic Index for Areas (SEIFA), an index that measures different aspects of social and economic advantage and disadvantage across Australia. The 4 orthogonal component variables that are included in our model are: the Index of Relative Socio-Economic Disadvantage, the Index of Relative Socio-Economic Advantage and Disadvantage, the Index of Education and Occupation and the Index of Economic Resources (Australian Bureau of Statistics, 2011). These variables provide good discrimination of income and other socio-economic trends in different locations across NSW. We also tested an 'imputed income' approach, but this resulted in diminished model performance (see Supplementary Material).

2.5. Random utility modelling

When respondents divide their recreation time amongst multiple sites, their preference is shown by the amount of recreation time that is allocated to each site. The ordered choice model has previously been used to infer recreational preference for different attractions at an amusement park, based on the number of hours allocated to each of the different attractions on offer (Kemperman et al., 2003). It can equally be applied to a situation where each respondent allocates a different number of leisure days within a specified period to different sites from a set of recreational alternatives. In our study we use the frequency of respondents' visitation to any and all of 728 national parks within the NSW protected area network over the preceding four week period to infer their preferences for specific sites and their underlying attributes.

The nature of the choice situation we are modelling, and the associated dataset, has direct consequences for our model selection. First, our survey allowed respondents to select multiple sites from a single choice set. Accordingly we used a repeated measures (panel) modelling format to account for respondents who visited multiple parks over the relevant period. Second, it included information on the intensity of respondents' preferences for each site visited (number of visits made to each site in the preceding 4 week period, with 0, 1, 2, 3, 4, or 5+ visits to each of the visited sites reported in panel format for up to 5 sites). Given these characteristics of our dataset, we have used a random effects ordered logit model to identify the amount of utility that would be required at a given site to generate 1, 2, 3….visits to a specific site (up to 5 or more visits in our model). The number of visits made by an individual to a specific site is estimated as the weighted average of the probability that a respondent will make 0, 1… 5+ visits, and is given by:

$$No.\ visits = \sum_{X=0}^{5+} [\,(exp(\mu_x - utility)\,/\,(1 + \exp(\mu_x - utility))\ .\ x)] \tag{1}$$

where x is the number of visits made to the site and μ_x is the threshold utility value at which x visits will be made to the site. Using an ordered logit model to incorporate information on frequency of visitation captures additional insights into visitor behaviour compared to other count models, like Poisson or negative binomial models that are more commonly used in travel cost studies (Hensher et al., 2015), and has allowed us to investigate the distribution of recreation values across the population. See Train (2009); Hensher et al. (2015) and Ardeshiri and Rose (2018) for more detailed discussion of ordered logit model theory and estimation. We discuss conceptual limitations associated with other potential choice model formats (repeat discrete choice or nested choice formats), if they were to be applied to our specific choice situation, in the Supplementary Materials.

We estimated utility as a function of various site, region and demographic characteristics according to the equation:

Utility = f (travel cost, park size, conservation status, remoteness, park values, infrastructure provision, on-park substitutes, off-park substitutes, respondent demographics) + error (2)

Our modelling incorporated data on a broad range of national park attributes considered likely to influence rates of tourism or recreational visitation. These include characteristics relating to park size, IUCN conservation status and remoteness, and presence or absence of specific natural values like marine values, caves, rivers and aboriginal or cultural heritage values. We also identified and included 9 classes of built infrastructure that we considered likely to influence rates of tourism or recreational visitation (Table 1). It was considered likely that selected park attributes (park size, quantities of built infrastructure) would be associated with some degree of diminishing returns. Diminishing returns assumptions were tested by comparing a number of models where the shape of infrastructure terms was varied (linear returns from infrastructure; square root diminishing returns; logarithmic diminishing returns). Models were assessed on the basis of corrected- Akaike's Information Criterion (AICc) to determine which of these assumption returned the best model fit following Anderson (2008). Our final model included $\log_{10}$ transformation for park size, length of roads, length of walking track and parking areas, and square root diminishing returns for remaining infrastructure types.

We recognise the effect that weather (temperature, precipitation) may have on survey respondents' decisions to make a recreational trip, as well as their site selection (Maddison, 2001; Jones et al., 2017). Ideally our model would include information relating to the weather conditions associated with each individual trip included in our dataset. This type of analysis was not possible given the nature of our survey process, whereby respondents were asked about their visitation to a range of parks over a 4 week period, without requiring them to assign each visit to a specific date within that period. We do not consider this to be a major limitation for this study. Our literature search did not identify any travel cost studies of park visitation that included climate information specific to individual trips. Of the relatively small number of park visitation studies that include weather variables, most employ averages over some aggregate period, or simply specify the season in which each visit was made. A seasonal (quarterly) approach has been used by Kolstoe and Cameron (2017) in their travel cost analysis of bird-watching sites in two U.S. states, and by Maddison (2001) and Lise and Tol (2002) in their analyses of the impacts of climate change on global travel patterns. Melstrom and Vasarhelyi (2018) use a coarser measure of seasonal temperature (regional averages for the January to March and October to December periods) to account for weather-related effects in their RUM of park visitation in the U.S.A.

We have sought to include the influence of weather on travel to NSW national park sites by including 'survey wave' as an independent variable in our model. 'Survey wave' refers to the timing of each respondent's interview (noting that the survey included 13 waves, spaced at 4-weekly intervals throughout the year, and that respondents were asked to provide information about the 4 week period immediately preceding their interview). Our 'survey wave' (approximately monthly) approach provides finer scale resolution of weather patterns than the seasonal (typically quarterly) approach used in the studies listed above. It also has an additional advantage in that it aligns holiday and non-holiday periods, including public holidays, across multiple survey years. We recognise that finer scale impacts of weather can only be understood by including weather variables specific to each trip (ideally at the origin and the destination) and recommend this as an area of future study, particularly with a view to understanding the effects of a changing climate on patterns of park visitation and other nature-based tourism.

Throughout our analysis we have retained information about non-visitors. Each survey respondent who reported that they did not visit a national park was assigned to a specific national park, randomly selected from the 274 (out of 728) parks for which the population surveyed by Roy Morgan reported no visits. We reported a 'zero' visit for each respondent at their designated park and analysed visitation using a single-stage model. This is analogous to pseudo-absence techniques that have been described in the ecological literature (Warton, 2005). This approach ensures that visitors' values for protected areas are moderated by non-visitors' 'zero' value reported against a relevant park within the choice set, and yields a more realistic and representative value of recreation in protected areas that can be scaled to the broader population. A sensitivity analysis demonstrating that pseudo-absence data augmentation provides improved agreement between model parameters from choice modelling and those from a regression analysis of an independent visitor count dataset is provided in an associated publication.

We accounted for substitution effects from alternate national park sites by including terms relating to infrastructure availability at alternative national parks located within reasonable travel distance from the park of interest. We calculated the combined total amount of infrastructure present from all parks within the relevant National Parks and Wildlife Service (NPWS) area, excluding the park of interest (there are 50 NPWS areas delineated across the state). We modelled substitution effects using the interaction term *infrastructure (park) * infrastructure (area)* for each of the nine infrastructure types presented in Table 1. Substitution effects may also occur in response to availability of non-park infrastructure located within a reasonable travel distance from the

Table 1
National park attributes considered likely to influence rates of tourism or recreational visitation, rationale for inclusion and data sources.

Park attribute	Units	Rationale
Size	*ha*	Larger parks may be associated with higher visitation (e.g. by offering more recreational opportunities, reducing crowding)
Remoteness	*ARIA+ + score (1-15; score of 14.1 for most remote park in NSW)*	This variable captures the location of national parks in relation to population centres, and acts as a proxy for non-park tourism infrastructure like roads, and retail and accommodation services
Conservation status	*IUCN conservation category (1-5)*	This variable has been selected to represent the biological and other natural values contained within national parks. NSW national parks IUCN conservation status range from 1 - 5 depending on conservation values and associated management objectives (Category 1 denotes the highest conservation status).
Natural values	*Presence / absence*	Presence or absence of each of 6 values (Aboriginal heritage, historic heritage, marine or estuarine areas, rivers or wetlands, high biodiversity value, caves and other landforms). Values were assessed by local parks staff as park of NSW OEH 'State of the Parks' reporting (NSW OEH, 2013).
Built infrastructure	*Quantity*	Quantity of built recreational infrastructure in each of 9 categories (paths and walking tracks (km), lookouts and other features (no.), roads (km), built retail outlets (no.), build accommodation (no.), day-use areas (no.), camping facilities (no.), parking areas (m^2), amenities (no.))

national park of interest. We used the Australian Remoteness Index for Areas (*ARIA+ +*) as a proxy for the amount of infrastructure and services likely to be available within a tourist or park visitor's choice set (University of Adelaide, 2015). We modelled substitution effects using the term *infrastructure (park) * ARIA+ +* for each of the nine infrastructure types presented in Table 1. Hanink and White (1999) used a similar spatially lagged indicator to model substitution effects. All interaction terms that were included in our model are shown in Table 3.

Each of the states adjoining NSW that were included in our study (Victoria, Queensland, and the Australian Capital Territory) have their own network of protected areas, as well as a variety of other greenspace and recreational opportunities on offer for local residents. This means that the NSW protected area network, which is the focus of this study, will be associated with a different set of substitute sites in each of the states of interest. This is also true at the sub-state scale; regional populations in each of the three large states surveyed (NSW, Victoria and Queensland) will have a very different set of recreational sites and options available to them compared to their metropolitan counterparts. We have included a region-specific constant for each of seven geographic regions included in our model (see Table 3) to account for this fundamental difference in the choice set that is available to residents in different locations within our very large survey region. These region-specific constants may also capture a range of other (unobserved) differences between respondents in different regions - for example, around recreation culture, or willingness to drive long distances.

Our model does not include any explicit term relating to travel cost and / or travel distance to the nearest substitute site, but we do account for travel distance to substitute sites indirectly in a number of ways. First, the region-specific constant described in the preceding paragraph can account for inter-regional differences in the spatial configuration (density, spacing) of substitute sites in different parts of our study area to some degree. Second, our retention and treatment of data relating to non-visitors, in combination with our very large sample size, means that we have documented the travel distance from every postcode within the study area to a reasonably large number of sites (mean count of 40 postcode-to-park trips are recorded for each postcode). This includes any case where survey respondents reported no visit to a NSW national park, and were subsequently assigned a 'zero' visit to a randomly selected low-visitation park within the network. This process records the distance from each postcode to a range on non-selected substitute sites, and has the additional advantage of categorising the site in terms of the full suite of attributes modelled - i.e. it records both travel distance and recreational quality at the substitute site(s).

2.6. Scaling up

We estimated the value of tourism and recreation across the NSW protected area network in terms of consumer surplus using the equation:

$$CS = - U / \beta_{travel\ cost} \quad (3)$$

where CS is the consumer surplus per visitor per trip, U is utility calculated for each individual respondent using the modelled utility function (Eq. (2)) and $\beta_{travel\ cost}$ is the model coefficient for our 'travel cost' term (Neher et al., 2013).

We have calculated consumer surplus using the method recommended by Hensher et al. (2015) for ordered logit models. We acknowledge there has been debate in the literature around the relative merits of using various techniques for the calculation of welfare effects - i.e. compensatory or equivalent welfare measures (e.g. see Lancsar and Savage, 2004 advocating use of compensating variation techniques detailed in Small and Rosen (1981), and see also Ryan, 2004 and Santos Silva, 2004 for their responses). We consider that the specifics of our study meet the criteria for which even critics like Lancsar and Savage (2004) agree that use of consumer surplus is appropriate: we are estimating the total value of an entire product or program (the protected area network in its entirety). Moreover, Train (2009) demonstrates that Small and Rosen's formula for compensating variation can be simplified to our Eq. (3) by replacing income data (which is generally not available) with price data.

We have used the number of adults in each of the relevant states (NSW, Queensland, Victoria and the Australian Capital Territory) (Australian Bureau of Statistics, 2018) to scale up from the survey population to state-level estimates of visitation and value. Postcode data contained within the Roy Morgan survey data set was used to weight estimates of parks visitation and value to ensure that the survey population was as representative as possible of the broader population, and accounted for income and other socio-economic trends captured in the SEIFA index. We also scaled visitation based on 'survey wave' to account for the timing of each survey respondent's interview.

3. Results

3.1. Survey statistics and model diagnostics

Of 62,216 survey respondents, nearly 7,000, or approximately 11% reported that they had visited a protected area in NSW over the preceding 4 week period (Table 2). This proportion was higher for NSW residents (23%) and lower for residents from adjacent states (12%, 3% and 1% for the Australian Capital Territory, Queensland and Victoria respectively). Almost one third of recent visitors reported that they had made multiple visits to protected areas within the preceding 4 week period; again, this proportion was slightly higher for NSW residents (35%), and lower for residents of other states (24–27%; Table 2).

Model coefficients are presented in Table 3. We report a significant negative correlation between visitation rates and travel cost, consistent with economic theory and the broader travel cost literature. We also report a reasonable sign for other model coefficients presented in

Table 2
Sample population by state showing number of visitors, visitor proportion, and frequency of multiple visits by individual survey respondents.

	RESPONDENTS		VISITORS		VISITORS - MUTIPLE VISITS		VISITORS - MUTIPLE PARKS	
	no. individuals	% of sample	no. individuals	% of state sample	no. individuals	% of state visitors	no. individuals	% of state sample
NSW	23815	38.3	5414	22.7	1885	34.8	1804	33.3
ACT	7762	12.5	946	12.2	217	22.9	270	28.5
QLD	15298	24.6	404	2.6	87	21.5	104	25.7
VIC	15340	24.7	210	1.4	56	26.7	37	17.6
	62215	100	6974	11.2	2245	32.2	2215	3.6

ACT = Australian Capital Territory, QLD = Queensland, VIC = Victoria.

Table 3, noting that the negative sign of selected protected area values and infrastructure are moderated by interaction terms such that all estimates of demand arising from these attributes are context specific. For a robustness check we have compared model coefficients obtained from our ordered logit model and those from a Poisson count model. We find good agreement between the Poisson and ordered logit models. While the magnitude of variables differs between the two models, as observed by Pendleton et al. (1998) and Pendleton and Mendelsohn (2000), the relative contribution made by each variable (based on the sign and relative magnitude of model coefficients) is consistent, with Pearson correlation between coefficients from the two models = 0.89. This result is unsurprising, given that ordered choice and Poisson are both count models, and both analyses employ a utility theoretic framework, but the results of our comparative modelling approach have been included to build confidence in model outputs amongst those who are unfamiliar with the ordered choice model, and to allow easy comparison of the value estimates obtained in our study with those from other recreation valuation studies that have employed more traditional count model techniques. Model coefficients from the Poisson model are also provided in Table 3.

The coefficients shown in Table 3 can be used to assess the relative utility of a broad range of park attributes like natural values and built infrastructure, and to estimate their relative contribution to recreational demand for protected area sites. The significant interaction terms relating to site remoteness and the availability of recreation substitutes indicates that different site values, and different types of built infrastructure, will confer different levels of utility depending on these contextual factors. This has important implications for protected area planning at both site and network scales. Implications for protected area planning and management are discussed further in an associated publication (Heagney et al., 2018).

3.2. The value of tourism and recreation in NSW protected areas

We estimate the total value of tourism and recreation services provided by the 728 sites within the NSW protected area network at $AUD 3.3 billion per annum. More than 98% of this value accrues to NSW residents, who visit protected areas within NSW more frequently, and enjoy lower travel costs and higher consumer surplus per visit, than residents of adjacent states (Table 4). We estimate that, on average, NSW residents make 5 visits to protected areas each year, and derive ˜ $90 in consumer surplus from each visit. The consumer surplus associated with visiting individual parks varied considerably. Consumer surplus arising from a visit to one of the highest profile parks within the network was roughly three to eight times the average ($331 per visit for NSW residents visiting Kosciusko National Park, $685 per visit for Royal National Park and $686 per visit for the Blue Mountains). This demonstrates and validates the rationale for our use of a whole-of-network sampling approach to avoid inflated value estimates that can arise from over-sampling at high profile parks.

Our use of an ordered logit model allowed explicit examination of the distribution of tourism and recreation value amongst individuals. We used visitation thresholds specified by our discrete choice model (Table 3) to predict the number of NSW residents in each of 4 discrete visitation categories (Table 5). We found that 48% of individuals are likely to visit a site within the NSW protected area network at least once a year. A large number of individuals are predicted to make multiple visits to protected areas, with another 48% of all visitors likely to make 2–8 visits to a protected area each year (Table 5). This finding indicates that the tourism and recreational services provided by the NSW protected area network are shared amongst a relatively large proportion of the community. However, our subsequent analyses suggest that the distribution of value amongst visitors, in dollar terms, is somewhat skewed. Using the average consumer surplus figures for NSW presented in Table 4, we predict that approximately 15% of total consumer surplus accrues to the ˜50% of individuals who visit protected areas relatively infrequently (once per year), while 25% of consumer surplus accrues to the 4% of individuals who visit protected areas monthly or even more frequently. This equates to a 20-fold difference in consumer surplus accruing to the most avid national park users in the state, compared to those who visit only once per year (Table 5).

We have compared our estimate of the value of tourism and recreation services provided by the NSW protected area network with the value of alternative, often competing, land-uses like agriculture and forestry on a per hectare basis. We compare land-uses in terms of gross value of production. We estimate the gross value of tourism and recreation expenditure arising from the NSW protected area network at $10.4 billion per annum (Table 6). Comparative figures place the average gross value of agriculture across NSW at $12-16 billion per annum, with grazing valued at $6.3–10.5 billion per annum, and cropping valued at $5.7 – 5.9 billion per annum. Public forestry production value is estimated at $0.46 billion per annum. (Table 6, Fig.1). Sources used to derive value estimates for expenditure and production across these comparative land-uses are provided in Table 6. These figures demonstrate that, within NSW, the gross value of tourism and recreation from protected areas is comparable to the economic value of extractive industries that represent alternative uses of protected area sites.

4. Discussion

4.1. The recreation and tourism value of the NSW protected area network

Our modelling estimates the value of tourism and recreation services provided by the NSW protected area network at $AUD 3.3 billion per annum. The per-capita estimates of consumer surplus provided in this paper are not dissimilar to published values of consumer surplus reported from other travel cost studies. Zandersen and Tol (2009) undertook a meta-analysis of travel cost studies relating to forest sites from 29 countries across Europe. Their estimate of average consumer surplus per visit of €17.30 (in year 2000 Euros) is equivalent to $AUD 34 (in 2015 dollars); very close to our estimate of average consumer surplus of $31 per visit (for visitors from all states combined; Table 4). Neher et al. (2013) analysed travel cost data collected at 58 national parks across the USA and estimated an average per-visit consumer surplus of $US 102, similar to our estimate of surplus of $90 per visit

Table 3
Model coefficients and robust standard errors for all model parameters.

Effect type	Dependent variable	Units	Ordered Logit		Poisson	
			Coefficient	Std. Err	Coefficient	Std. Err
Constant			−3.034 ***	0.156	−3.923***	0.179
a) National park characteristics						
Travel cost		$, 100s	−0.403***	0.013	−0.003***	0.000
National Park attributes and values	Conservation status	IUCN cat	0.074***	0.024	−0.039	0.028
	Remoteness	ARIA++	−0.159***	0.031	−0.109***	0.027
	Size	log(ha)	−0.091**	0.045	−0.002***	0.000
	Aboriginal heritage		0.493***	0.074	0.401***	0.089
	Historic heritage		−0.177*	0.095	−0.225*	0.122
	Caves and other landforms		0.234**	0.091	0.086	0.124
	Marine or estuarine		0.165*	0.099	−0.289**	0.127
	River or wetland		−0.719***	0.100	−0.507***	0.144
	Natural values		−0.585***	0.092	−0.493***	0.115
	Aboriginal heritage * ARIA++		−0.007	0.026	−0.075**	0.030
	Historic value * ARIA++		−0.151***	0.033	−0.103***	0.038
	Caves & landforms * ARIA++		−0.098***	0.031	−0.041	0.039
	River values * ARIA++		0.273***	0.034	0.179***	0.042
In-park infrastructure	Paths & walking tracks	log km	0.723***	0.045	0.681***	0.056
	Lookouts & other features	√no	0.036	0.033	0.039	0.082
	Roads	log km	0.259***	0.034	0.225***	0.028
	Built retail outlets	√no	0.444***	0.073	0.803***	0.226
	Built accommodation	√no	−0.167***	0.038	−0.202*	0.108
	Day-use areas	√no	−0.483***	0.054	−0.024	0.165
	Camping areas	√no	−0.308***	0.060	0.423**	0.169
	Parking areas	log 100s m2	0.609***	0.050	0.441***	0.073
	Amenity blocks	√no	0.046	0.050	0.163*	0.090
Interaction terms (in-park infrastructure)	Paths & walking tracks	Infrastructure at park of interest (transformed as above) * infrastructure in relevant NPWS area / 1000	−0.044***	0.004	−0.035***	0.005
	Lookouts & other features		0.019***	0.004	0.056	0.044
	Roads		0.000	0.001	−0.182***	0.041
	Built retail outlets		−0.655***	0.107	0.056**	0.028
	Built accommodation		0.032***	0.005	−0.189***	0.018
	Day-use areas		0.275***		0.042	0.026
	Camping areas		−0.054***	0.020	−0.008	0.009
	Parking areas		−0.055***	0.015	0.130**	0.052
Interaction terms (non-park infrastructure & services)	Paths & walking tracks	Infrastructure at park of interest (transformed as above) * ARIA++ at park centroid	−0.125***	0.014	−0.019	0.028
	Lookouts & other features		0.0170	0.015	0.180***	0.041
	Roads		0.019**	0.008	0.063	0.039
	Built retail outlets		0.121***	0.028	−0.042**	0.018
	Built accommodation		−0.033**	0.015	−0.075**	0.030
	Day-use areas		0.119***	0.025	−0.103***	0.038
	Camping areas		0.100***		−0.041	0.039
	Parking areas		−0.0160	0.012	0.179***	0.042
b) Respondent characteristics and survey timing						
Respondent home region	NSW metro		1.118***	0.104	1.143***	0.117
	NSW regional		1.348***	0.107	1.406***	0.118
	ACT	dummy coding	0.856***	0.152	0.497***	0.181
	VIC metro		−0.1090	0.125	−0.505***	0.156
	VIC regional		0.1460	0.161	−0.245	0.186
	QLD metro		−0.0780	0.135	−0.192	0.161
	QLD regional		−0	–		
Respondent characteristics	Sex		−0.233***	0.041	−0.275***	0.050
	Age_18-24		−0.1010	0.072	0.017	0.088
	Age_25-34	dummy coding	0.0970	0.060	0.170**	0.074
	Age_35-49		0.141***	0.054	0.181***	0.066
	Age_50 +		−0	–		
	Children in household	no.	−0.0050	0.021	−0.036	0.026
Socio-Economic Index for Areas	Economic opportunity (IEO)		0.037*	0.020	0.034	0.024
	Advantage & disadvantage (IRSAD)	Index as per Australian Bureau of Statistics (2011)	−0.119***	0.045	−0.097*	0.054
	Disadvantage (IRSD)	+ve values indicate lower levels of disadvantage	0.140***	0.039	0.099**	0.047
	Economic resources (IER)		−0.0040	0.016	0.001	0.019
Survey year	2008		0.652***	0.058	0.510***	0.072
	2010	dummy coding	−0.199***	0.063	−0.119	0.081
	2012		−0.214***	0.061	−0.172**	0.081
	2014		−0	–		
Survey wave	1		0.0000	0.000		
	2		−0.0260	0.090	0.244***	0.080
	3		−0.332***	0.098	0.083	0.085
	4		−0.450***	0.098	−0.048	0.090

(continued on next page)

Table 3 (*continued*)

Effect type	Dependent variable	Units	Ordered Logit		Poisson	
			Coefficient	Std. Err	Coefficient	Std. Err
	5	dummy coding	−0.1500	0.095	0.129	0.082
	6		−0.426***	0.097	−0.023	0.085
	7	Waves represent successive 4-week periods throughout the year	−0.411***	0.099	−0.051	0.086
	8		−0.372***	0.099	−0.093	0.090
	9		−0.609***	0.106	−0.218**	0.098
	10		−0.510***	0.101	−0.168*	0.094
	11		−0.285***	0.096	0.057	0.084
	12		−0.186*	0.095	0.138*	0.083
	13		−0.372***	0.097	−0.085	0.087
c) Visitation thresholds						
	Mu(01)		2.882***	0.048		
	Mu(02)		3.946***	0.060		
	Mu(03)		4.419***	0.067		

***, **, * denote significance at 1%, 5%, 10% level respectively.

Table 4
Average number of visits and consumer surplus (per adult visitor) and scaled to total adult population by state.

	Individuals Aged 18+ millions	No. visits per individual mean p.a.	No. visits total millions p.a.	Consumer surplus per visit $, mean	Consumer surplus total $M, p.a.
NSW	6.2	5.8	36.0	89.5	3218
ACT	0.3	1.8	0.5	23.8	13
QLD	5.1	0.8	4.1	8.2	33
VIC	3.8	0.3	1.0	0.7	1
Total			42	30.6	3265

ACT = Australian Capital Territory, QLD = Queensland, VIC = Victoria.

reported for NSW residents only (which is the relevant population for comparison in this instance).

We note that the value of tourism and recreation presented in this paper is *not* the value of the protected area network itself; it is a partial value. Protected areas provide a broad range of ecosystem services, like carbon sequestration and water filtration (Chan et al., 2006; Dudley and Stolton, 2010; Palomo et al., 2013). Global growth in carbon markets, water trading schemes, and biodiversity offset markets provide increasing opportunity to attach monetary values to some of these services, which could be added to the value estimates for tourism and recreation provided here. Protected areas also have a range of non-use values, like existence and bequest values (Turner et al., 1994; Phillips, 1998; Haefele et al., 2016). Under a total economic valuation framework (Turner et al., 1994) these are generally considered to be additional to the value of ecosystem service provision. A recent choice modelling survey undertaken in the US concluded that the non-use values of protected areas and associated conservation and education programs was at least as large as the estimated recreation value (Haefele et al., 2016). It follows that the value estimates of tourism and recreation provided in this paper should be treated as a minimum-bound estimate of the value of the NSW protected area network.

4.2. Distribution of tourism and recreation values from NSW protected areas

Almost the full value of tourism and recreation reported in this study accrued to residents of NSW. Given that Australian protected areas are under the jurisdiction of individual states, this may be considered a ‘plus’ in the context of using value estimates from travel cost modelling to justify protected area management expenditures. Although the tourism and recreation value accruing to populations of adjacent states was small in terms of consumer surplus, the value of interstate visits *to NSW* could alternatively be estimated through producer surplus arising from interstate visitor expenditure within NSW. Given the relatively high rates of visitation observed from interstate populations (Table 2) this may represent a substantive increase in the tourism and recreation value of the NSW protected area network as viewed from a jurisdictional perspective.

Our results indicate that the recreation and tourism benefits of protected areas in NSW are shared across a large number of households. Again, this can be considered a plus for policy-makers, as it suggests that there is likely to be broad-based support for ongoing investment in management and maintenance of protected areas. We note however, that the tourism and recreation values observed in this study were heavily skewed across visiting households, with more frequent visitors enjoying a great proportion of value. While distributional effects are not of immediate concern when undertaking economic valuation, they are likely to be of considerable importance to policy-makers for a variety of reasons, discussed below.

In some instances, the concentrated accumulation of value to a small proportion of users could be considered a case for charging entry fees to protected areas. A number of studies that have used travel cost modelling (or other methods) to investigate the impact of entry fees indicate that demand for protected areas is inelastic (Gelcich et al., 2013; Pascoe et al., 2014; Stevens et al., 2014), and unlikely to be substantially impacted by the introduction of an entry fee. However, it is also important to note that a skewed distribution of value is not necessarily a negative outcome in terms of social equity. Blaine et al. (2015) report a significant interaction between income and travel cost,

Table 5
Average number of visits and consumer surplus (total and proportion) accruing to NSW households, by frequency of visitation.

Visitation Frequency	No. Visits per annum	% of visitors	CS per visit	CS per individual	Total CS accruing	% of total CS
Once a year	1	47.8	85	89	477,065	14.8
2-3 times per year	2-3	33.1	89	223	826,392	25.6
~Quarterly	4-8	15.1	107	642	1,087,574	33.8
~Monthly or more	9+	4.0	130	1850	830,946	25.8

Table 6
Comparative per-ha values for protected areas (tourism and recreation values only) and selected alternate land uses. All values are gross value: gross value of goods produced for agriculture and forestry, gross tourism expenditure for protected areas. Reference year is 2008 as this year included a survey of land-use areas; values have been updated to $2014.

Land-use category	Gross value ($ 2014 Billions)	Area (M ha in 2008)	Source (value)	Source (land area)
Protected Areas	10.4	7.0	Tourism Research Australia, 2014	NSW NPWS (2016)
Agriculture ^	16.1 (12.1)	20	Australian Bureau of Statistics (2008), (2012a)	Australian Bureau of Statistics (2013)
Cropping	10.5 (6.25)	10		
Grazing	5.7 (5.86)	10		
Forestry (public) ^^	0.46	1.4	Timber (2016)	Australian Bureau of Statistics (2012b)

^^ max value at recent peak in global wood prices. Prices have since declined.
^ 2008 was a drought year; to minimise any bias we have also included equivalent. estimates of gross value of agricultural production from 2014 in brackets (from Australian Bureau of Statistics, 2015d).
TRA = Tourism Research Australia, ABS = Australian Bureau of Statistics, NPWS = (NSW) National Parks and Wildlife Service.

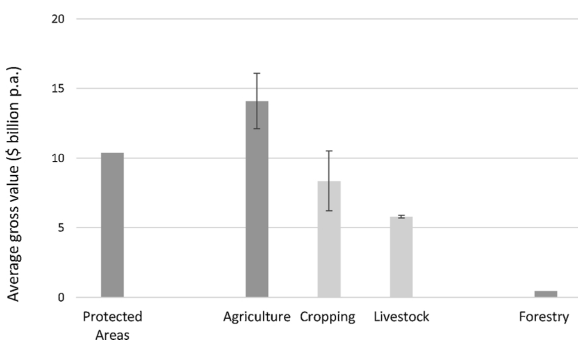

Fig. 1. Average gross expenditure value of tourism and recreation in NSW protected areas compared with gross value of agriculture and forestry production. Error bars show range from 2 years of agricultural production data: 2008 (drought year) and 2014 (non-drought year).

such that high-frequency visitors tend to be local residents with lower incomes. While explicit income data was not available for our study, coefficients for other included demographic variables suggest higher rates of visitation by people living in regional areas. This trend was consistent across all surveyed states (Table 3). This suggests that the protected area network across NSW is providing important recreational services to regional communities, who generally experience lower levels of income and higher levels or deprivation than their metropolitan counterparts (Dollery and Soul, 2000). Coefficients relating to SEIFA variables can be difficult to interpret. National park visitation was positively associated with higher levels of economic opportunity (as described in the IEO component) and low levels of disadvantage (as described in the IRSD component) but negatively associated with the IRSAD component which measures advantage and disadvantage within an area (Table 3). This suggests that park visitors are less likely to come from highly advantaged areas, and more likely to come from middle and working class areas of the state.

The frequency of protected area visitation is also relevant in relation to public health objectives. There is increasing evidence that protected areas can contribute to physical and mental wellbeing (see Kabisch et al. (2015) for a recent review). It follows that policy-makers may seek to encourage more frequent visitation to protected area sites. Our use of a discrete choice model is informative in this context; it shows that there is a lesser and diminishing threshold required to increase frequency of visitation (from 1 to 2 visits, or from 2 to 3 visits etc.) than to encourage a non-visitor to make their first visit to a protected area site (see 'visitation threshold' values in Table 3). Obviously increasing both the visitor base *and* the frequency of visitation are desirable, but our results suggest that easiest and most cost-effective gains are likely to be made by focussing on the existing visitor market.

4.3. Protected area values and trade-offs with alternate land-uses

Results of travel cost modelling of recreational demand can be used to balance arguments in favour of extractive use and to justify ongoing management expenditure (Beal, 1995; Saraj et al., 2009; Samos Juarez and Bernabeu Canete, 2013; Balmford et al., 2015). The comparative values presented in our study indicate that the tourism and recreation services provided by protected areas (and other forest sites) can be a similar order of magnitude to the extractive uses that are traditionally assigned economic values on a state-wide basis, despite the smaller land area that is currently designated to protected area management (Table 6). In this context our results lend weight to economic case for ongoing investment in the management of the NSW protected area network.

Even though we report high values for NSW national parks compared to some other land-uses, decisions about land-use trade-offs should be made with caution. Our study indicates there is a large degree of spatial variation in the tourism and recreational value of different protected areas within the NSW network, as well the range of other land-uses presented in Table 6 (Polasky et al., 2005; Naidoo and Ricketts, 2006). Moreover, the comparison presented in Table 6 is somewhat simplistic. Most land-uses, and especially those listed in Table 6, which each retain some degree of 'naturalness', offer some range of ecosystem services. For example, forestry sites may offer similar ecosystem services to protected areas, in terms of carbon sequestration and water filtration; where public access is allowed they may also provide recreation services (Bujosa Bestard and Font, 2010). Any trade-off between competing land-uses should account for the full value of all ecosystem services offered by each alternative within the specific local context.

There is also potential for ecosystem service trade-offs to occur within a protected area network. Tourism and recreation are not without impact; potentially serious impacts that are at odds with protected area conservation objectives include erosive and compaction effects from vehicle and foot traffic, the accidental introduction of weeds, and, perhaps most pertinently, the clearing of vegetation for the provision of recreational infrastructure (Pickering et al., 2007; Esteves et al., 2011). In this context, we caution against 'measurement bias', whereby protected areas are managed to optimise tourism and recreation simply because it is possible to assign an economic value to them (a continuation of the problems associated with non-market goods). Quantifying and reporting values arising from biodiversity conservation (especially non-use values) will help ensure an appropriate balance between conservation and recreation is achieved. Random utility modelling can also help, by identifying spatial variation in tourism and recreation value in response to underlying park characteristics (Beal, 1995; Font, 2000; Monz et al., 2010; Amoako-Tuffour and Martinez-Espineira, 2012) and directing tourism towards less ecologically sensitive sites within a protected area network (Fleming and Cook, 2008).

4.4. Conclusions

The high rate of protected area visitation reported in our study, and our concomitant value estimate of $3.3 billion per annum, underscores the importance of protected areas in providing recreational opportunities to the surrounding community. Even though this figure represents a lower-bound estimate for the value of a protected area network, it is already on par with the economic (extractive) values reported for agriculture and forestry, even despite the smaller land area that is currently designated to protected area management in NSW. Consequently, optimal allocation of land to maximise societal benefits is unlikely to be achieved without full and robust ecosystem service accounting (Bujosa Bestard and Font, 2010). Our study also underscores the importance of moving towards more representative survey formats if the results of travel cost studies are to be robustly and representatively incorporated into formal economic processes.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.landusepol.2019.104084.

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