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Valuing Protected Area Tourism Ecosystem Services Using Big Data

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Abstract

Economic value from protected areas informs decisions for biodiversity conservation and visitor benefits. Calculating these benefits assists governments to allocate limited budget resources. This study estimated tourism ecosystem service expenditure values for a regional protected area network in South Australia (57 parks) using direct transactional data, travel costs and economic multipliers. The big dataset came from a comprehensive booking system, which helped overcome common limitations associated with survey data (e.g., key areas rather than full network and high zero-value observations). Protected areas returned AU$373.8 million in the 2018–19 base year to the South Australian economy. The results indicate that combined estimation methods coupled to big data sets provide information on baseline expenditure to engage with critical conservation and tourism sites (e.g., Kangaroo Island). In this case they offer a unique full area network expenditure estimate which is an improvement on typical survey approaches, highlighting the advantage of protected area managers investing in big data. Finally, as South Australian protected areas exceed that in many other contexts the study offers important inputs to funding narratives and protected area expansion in line with global assessment targets.

Introduction

Protected areas such as national parks are public assets providing conservation and tourism ecosystem services (Driml and McLennan 2010). Protected areas supply large amounts of ecosystem services through the enjoyment of nature benefits, and underpin global efforts for the conservation of biodiversity (Watson et al. 2014). Ongoing investment in new and existing parks mean that terrestrial protected areas now cover 15.1% of global landmass (UNEP et al. 2019). However, this remains a shortfall against the 17% target set for 2020 in the 2010 Convention for Biological Diversity (i.e., the Aichi Target 11). The shortfall is further highlighted by recent estimates that the minimum terrestrial area required to secure the planet's biodiversity is approximately 44%, including protected areas and other land-use protections (Allan et al. 2022), and that the last decade of increase in protected areas has only resulted in partial improvement to a range of biodiversity components (i.e., threatened species, key biodiverse areas and ecoregions, and ecosystem services) (Maxwell et al. 2020). Fixing this shortfall will require substantial future public funding. However, a critical challenge for jurisdictions seeking to fund protected area expansion and management is the lack of data-driven methodologies for confidently valuing ecosystem service returns from protected areas, including returns from visitation and tourism (Balmford et al. 2015).

Funding for protected areas has not kept pace with growing demand for access to and use of conservation sites (Eagles 2003; Watson et al. 2014). This increases the risk of degradation of ecological resources and potentially undermines the quality of facilities needed to enhance and manage recreation and tourism ecosystem co-benefits. Global protected area management strategies must therefore mature to accommodate the complex interplay of demand for conservation, recreation, tourism, education and other ecosystem services within a paradigm where human use enhances conservation outcomes (Weaver and Lawton 2017). Improved capacity to capture big data sets from protected area users online is an opportunity for public asset managers, where that data is used to estimate complex ecosystem values from environmental services and tourism,

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and may assist in demonstrating to key national park stakeholders and decision-makers the benefits provided by such protected areas (Mulwa et al. 2018). Quantifying the economic returns from these sites is also necessary to improve choices about management priorities and the financing of relevant agencies essential to stewarding conservation and visitor benefits (TTF 2013).

Without proper valuation limited financial and political resources are bound to be misallocated (Bharali and Mazumder 2012), and so estimating the economic benefits of protected areas will assist in evaluating parks policy and management alternatives (Loomis 2002).

Because big data is usually unavailable, estimates of the tourism/recreational values for protected areas are commonly quantified using travel cost models (TCM) (Bharali and Mazumder 2012). Many economists support the use of TCM as a valuation tool for tourism sites as the technique relies heavily on revealed preferences from visitors (Anderson 2010) to estimate ecosystem benefits. In economic terms, benefits are measured as the difference between demand for a good and the cost of that good (Benson et al. 2013). Benefit estimates are needed to put into context the (relatively lower) costs of updating and replacing infrastructure to meet visitor expectations (ibid.). These decisions become particularly pertinent after large impacts on protected area assets from natural disasters such as the devastating summer fires in South Australia (particularly Kangaroo Island) in 2019–2020 (Li et al. 2021). Economic travel cost model values are therefore used to evaluate management options and interventions for optimizing welfare provision and assist in the comparison of tourism ecosystem benefits with conservation costs. Big data approaches may offer a useful alternative for those protected areas that invest in their collection and analysis, for reasons we explain below.

Literature Review and Contribution

The basic principle of TCM involves estimation of consumer surplus from *limited* data based on the Marshallian demand curve (Hotelling 1949). Thus, travel costs for national parks tourism can be challenging to quantify. Typical challenges include choosing an indicative site location, choosing the model specification, accounting for the opportunity cost of time, accounting for substitutes, multi-purpose or multi-destination trip handling, and the measurement of travel costs per visit (Gürlük and Rehber 2008). Prior protected area TCM valuation examples can be found for sites in Australia (Beal 1995; Heagney et al. 2019), Bangladesh (Kawsar et al. 2015), Turkey (Gürlük and Rehber 2008), Africa (Bharali and Mazumder 2012; Mulwa et al. 2018), Spain (Palomo et al. 2013), the United States (Benson et al. 2013; Haefele et al. 2016b; Richardson et al. 2018), and Nepal (Lamsal et al. 2016). The results of these TCM studies have been used to justify government expenditure on conservation management (Beal 1995), provide insights for decision-makers into visitor demographics or preferences (Benson et al. 2013), and to estimate the likely impact of new or altered site entry fees (Pascoe et al. 2014). Yet by necessity these studies commonly focus on a single high-visitor use site of interest, utilize site-specific or recall survey methods to capture visitor data, and rely on modeling to aggregate sample data to provide population estimates of tourism values. Like all valuation approaches this creates the need for assumptions that may be heroic.

As an alternative method, regional economic impact assessments (e.g., computer-generalizable equilibrium [CGE] modeling or input–output [I–O] tables) can be employed to estimate the values of protected areas (e.g., Duffield et al. 2013). I–O modeling typically focuses on the regional economic benefits of tourism and the use of multiplier analysis to measure beneficial economic impacts (Vaughan et al. 2000). Beneficial economic impacts arise because the money spent by a visitor circulates within the regional economy: known as the the multiplier process. The basis for I–O analyses is Leontief (1941) who used a system of linear equations to demonstrate the interdependence of industries within an economy. That is, the outputs of firms in one sector can be used as inputs for firms in other sectors, and so on (Rose 1995). However, I–O models also have limitations including the use of fixed coefficient production functions that prevent substitution between different production factors, and the use of non-survey data to obtain disaggregated country- or regional-level input–output accounts (Robison and Miller 1988). Further, other studies have argued that, while estimation errors may increase when compared to primary data-based estimates, the ordinal ranking of policy scenarios would be unlikely to change (Cline and Seidl 2010). Finally, the use of a fully-endogenized regional CGE model would rely on similar (or the same) input–output data and require the parameterization of a larger number of behavioral variables, thereby increasing empirical uncertainty. That said, the study of beneficial economic impacts can help communities determine appropriate policies to reach environmental economic goals, or direct government investment in regional areas (Cline and Seidl 2010).

Within this literature scope estimations of aggregate values for a whole protected area network remain rare, despite the network (or jurisdiction) being the scale at which resource allocation is usually set. Given the reported complexities around how to scale when aggregating site-specific travel cost data (Bestard and Font 2010), it is still unclear how site-specific results can be generalized to a broader protected area network scale. Values are typically reported piecemeal and recreation or tourism values for total networks remain unknown (Heagney et al. 2019). Further, studies of individual parks—or regional economic impacts—offer limited insight value for managers whose protected area networks encompass tens or even hundreds of individual sites (Richardson et al. 2017). Studies that focus on a small or incomplete number of sites may also ignore context-specific attribute differences, remoteness and local community factors, in addition to the availability of substitute sites within the surrounding region. Such bias is problematic as estimates at high-profile sites may obscure the attributes which drive visitation, and limit informed decision-making (Heagney et al. 2018). Moreover, value estimates from on-site surveys cannot be easily scaled up to provide a total estimate of tourism and recreation without robust data on total visitor numbers; and such data is usually absent from protected area or public sources (Heagney et al. 2019).

In response to these issues, Bestard and Font (2010) recommend simultaneous valuation of all relevant sites within a network to address scaling and aggregation complexities. In support, Heagney et al. (2018) argue that a broader range of national park sites be included in protected area valuation assessments to account for substitution effects, as well as a more diverse set of contexts to better inform management choices and the non-trivial zero-inflated responses resulting from large-scale population surveys. If possible, a more complete set of regional economic impact assessments should also be undertaken. To achieve such outcomes some researchers are turning to big data and its analysis. Big data (or high volume) analysis has been increasingly employed to investigate diverse social behaviors including urban park visits (Zhang and Zhou 2018). Finally, combination studies of non-market (e.g., travel cost estimates) and I–O modeling remain very rare in the literature (Cline and Seidl 2010) despite the advantages to more complete estimations of total economic values for national parks.

In this study we employ a booking system big dataset (i.e., 643,823 observations in 2018–19) for visitors to protected areas in South Australia which enables us to estimate simultaneous travel cost expenditures for each of the 57 revenue generating parks in the regional network (i.e., those outside of the Adelaide metropolitan area). This approach enables the avoidance of high-visitation biases, allows for substitutes where multiple trip details are recorded in the booking system, and accounts for rural remoteness in the estimations. Using these data we can also avoid as much as possible the inclusion of zero-value responses. As such, we can aggregate the values across the regional component of the protected area network and scale total tourism expenditure value estimates. No modeling is required given the data coverage, thereby assisting the avoidance of site dependent variable and specification choices. That said, values remain spatially incomplete due to missing metro park data. Despite the use of big data some missing data from regional parks has also been assumed to fill gaps in the series. Travel distances are also still assumed on the basis of mapping algorithms and may not be as accurate as recall survey responses. Finally, the input–output modeling of regional tourism contributions are themselves an estimate and not an accurate accounting exercise. As such, we estimate an annual demand function for a single year (2018–19) to provide a baseline measure ahead of future assessments. For more detail on our approach the study context, data and methods employed are detailed in the following sections.

The Study Context

South Australia's protected areas aim to conserve natural and biological heritage while providing people with access to use and non-use benefits (e.g., tourism). The entire network is comprised of 362 parks and reserves. Of this network we assessed the 57 revenue generating sites which represent the majority of regional protected areas (i.e., those outside the capital city of Adelaide) providing visitor access, amenities, camping and at some icon sites retail sales and tours. The scope of the study was a pre-Kangaroo Island major bushfire (late 2019) which destroyed a considerable component of one of the state's most popular protected areas, and the COVID-19 pandemic (2020–2021) which reduced total visitor numbers. This enables a benchmark period for later tracking of the recovery of protected area visitor use and the associated economic contribution of site tourism in future years.

The South Australian Department for Environment and Water (DEW) is responsible for managing the State's natural resources. The National Parks and Wildlife Service (NPWS) is responsible for management of protected areas, as well as recreational use by tourists. This is important to the state as tourism is a key sector of the South Australian economy, and visitors to protected areas represent a significant proportion of nature-based tourism activity. The economic influence of tourism is felt through both primary and secondary contributions. Primary contributions arise from visitor spending on park entry fees, campsite rentals, within-park accommodation, and retail sales at DEW kiosks etc.—that is, any expenditure incurred by a visitor as part of their direct access to and within a site. These contributions provide income directly to the state through the NPWS. Secondary contributions are the expenditure a visitor makes to travel to the site in regional areas so that they can enjoy facility/amenity benefits. This includes vehicle expenses (i.e., fuel, vehicle wear and tear), accommodation along the way depending on the travel time involved, and incidental

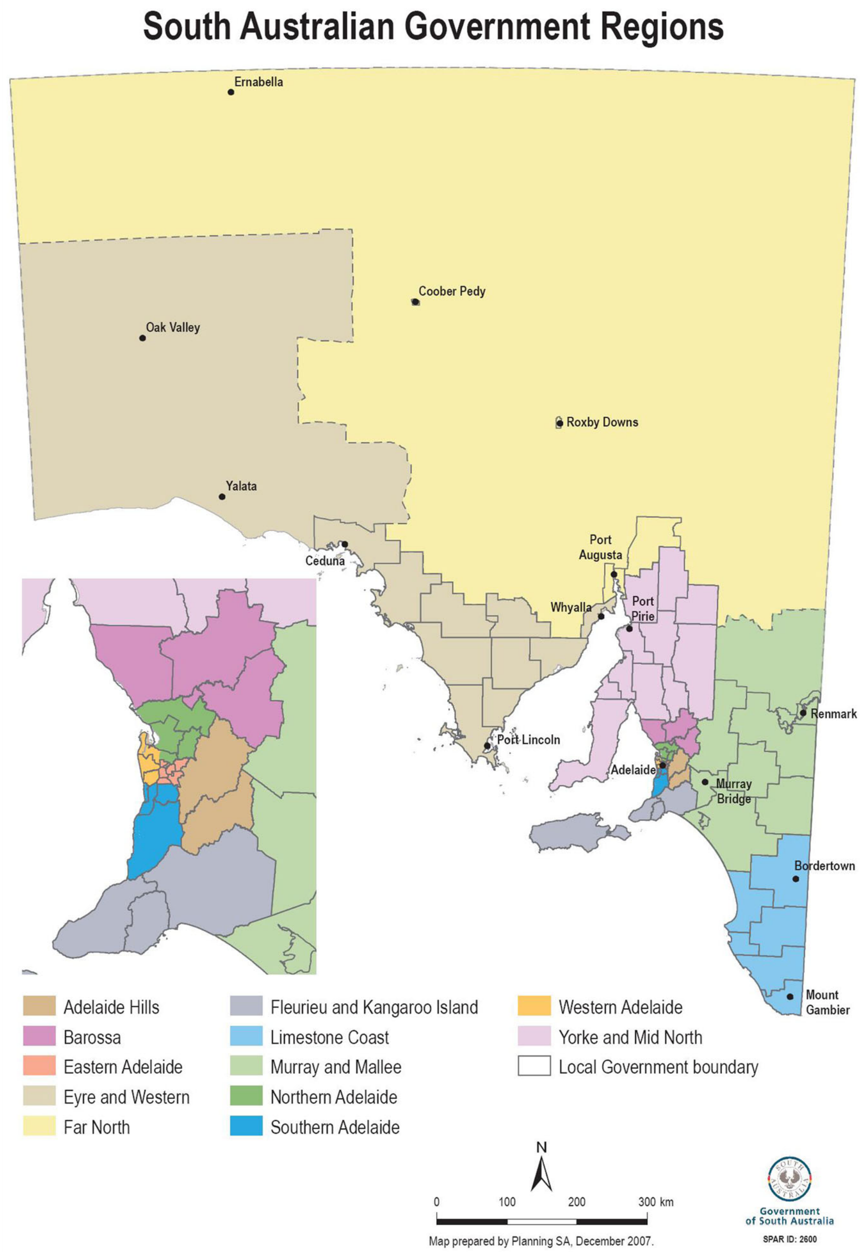

Fig. 1 Map of SA government regions for the RISE modeling (Department of Planning Transport and Infrstructure 2015)

meals or other expenditure. Secondary contributions therefore stimulate the economy as a consequence of visiting protected area sites via income stimulus passing through cash registers external to the NPWS; that is, via payments to other businesses and entities in the (regional) economy. Both primary and secondary economic expenditure contributes more broadly to regional, state and national economies because the benefits of the expenditure flow through the economy at different scales, creating multiplier effects. As such, the total economic benefits are greater than the initial amount incurred for travel costs. Economic multipliers can be derived from utility travel cost studies and state/regional economic activity multipliers developed for a range of sectors in the economy. In this report, we focus on travel expenditure and the multiplier contributions associated with regional protected areas: namely sites located in the Eyre & Western, Far North, Fleurieu & Kangaroo Island, Limestone Coast, Murray & Mallee and Yorke & Mid-North regional areas (Fig. 1).

Methods and Data

In this study we broadly follow the approach of Driml et al. (2019), excluding the use of direct interviews or survey instruments to collect data from visitors. Their study of four representative protected area parks in Queensland, Australia was used to estimate consumer surplus values which were scaled up to achieve statewide values. Like Driml et al. (2019), we are interested in calculating the money visitors spent traveling to protected areas in South Australia, staying in accommodation both along the way and near park and recreation sites, consuming food and beverages, engaging with commercial services (where available) and spending on other related items such as souvenirs, firewood, camping supplies etc.—but instead focusing on big data sources over surveys. The secondary travel expenditure data provides an approximate measure of the non-consumptive tourism and recreational ecosystem benefits of South Australia's protected areas as a baseline for the 2018–19 period. We cannot categorically state that all of the travel expenses incurred were for the primary purpose of a visit to protected areas, and therefore the values reported may be an overestimate of the true use significance to visitors. However, we are able to provide a baseline economic contribution estimate of travel expenditure. To improve on past studies, we attempt to obtain data and secondary economic proxy values for as wide a range of South Australian protected area sites in the regional network as possible. This approach allows us to estimate the aggregate contribution of protected areas to state and regional economies without the need for benefit transfer methods[1] or potentially biased and/or skewed econometric scaling approaches.

Data Sources

Key data was sourced from the DEW online visitor booking system *Bookeasy*. This is a central booking platform where visitors to (non-icon or low-visitation) South Australian protected areas must register their trip, planned destinations on that trip, dates of travel and other information to obtain a pass to enter and/or stay at a site. Visitors are required to enter their residential postcode with each booking, which enabled the designation of a starting location for each visit. Where postcode data was not provided, data registered via credit card payments (de-identified and fully sanitized of card numbers, expiry and authorization details) were sourced from *Bookeasy's* payment gateway to approximate the visitors' point of origin.

By contrast, bookings for icon (i.e., high-visitation) sites are not made entirely through the *Bookeasy* platform. High traffic volumes, high proportions of day-trip visitation, and higher value spend of visitors to these sites necessitates point of sale transaction analysis from facilities at the relevant site (e.g., staffed Visitor Centers). NPWS staff may collect demographic information (postcodes) from visitors during sales transactions. However, in some instances, postcodes are not collected owing to staff capacity and time constraints, among others. This limitation was an issue for our analysis as icon sites represent a significant proportion of the total economic activity in the regions. To overcome this, DEW provided partial postcode data from relevant icon sites; i.e., Seal Bay and Naracoorte Caves. Travel cost estimations based on recorded visitor origins were then extrapolated across all remaining icon site visitors within the same region. For example, Naracoorte Caves data recorded 37% of all visitation postcodes. Estimated travel expenditure values for that 37% were subsequently extrapolated across the remaining 63% of visitors and all Tantanoola Caves visitors (both sites are located within the Limestone Coast Region), again highlighting some limits to our big data approach. Likewise, for Kangaroo Island's Seal Bay visitation postcodes were extrapolated across Flinders Chase and Kelly Hill Caves visitor numbers. Finally, NPWS provided a complete set of operating budget data for 2018–19. This offered the capacity to contrast direct and indirect benefits to the costs, in both operating and capital expenditure terms, similar to other studies in Australia (see for example Driml et al. 2019). These data were used to simply compute the ratios of operating/capital expenses to benefits for study and management comparison purposes.

Data Treatment

The origin points (either postcode or credit card-based[2]) were then fed into a series of online public domain Australia postcode databases so that a spatial coordinate of origin (x–y) centroid point could be established for each record. While incomplete with respect to total distances traveled, this origin point provides an average value from each postcode location-equivalent across all of the relevant observations for a conservative estimation of the relevant travel expenditure. Postcode centroids/location data also enabled identification of State or Territory of origin to be integrated in the master database. The Collaborative Australian Protected Area Database (CAPAD) was used to create a final protected area destination (x–y) point for each trip. CAPAD records provide useful data on all national park and conservation sites and in this case averaged destination points since actual final destinations (e.g., within a park) are generally not available—though it is expected that visitors would be in the broad vicinity of these final centroid

[1] Benefit transfer methods are approaches to calculating economic benefits by taking the estimates of economic impact (or values in general) gathered from one site and applying them to another similar site.

[2] It is recognized that the mailing address may not always be the home address of the credit card holder, but we assumed that they were broadly related to one another for the purposes of setting an origin point for this study.

Table 1 Activity estimate—parameters and assumptions

Parameter	Source	Assumptions
Visitors	*Bookeasy*/point of sale data provided by DEW	Good data available for nights stayed and so no further assumptions needed.
Distance visitors traveled	Bing distance metrics as calculated by the University of Adelaide research team and CAPAD park location data	Postcode data either directly available or extrapolated from point of sale data (at limited sites, e.g., Seal Bay) for missing values based on correlation checks across sites and informed by allocation shares/proportions applying known state behavior to any missing postcodes over the sample. This provides a rough approximation of the origin site for each visitor (or group of visitors traveling on the same booking). All other visitors had travel distance in kilometers calculated between origin and destination sites. CAPAD data used to estimate final destination point for each trip.
Visitors staying at least one night or two or more nights	*Bookeasy* data as provided by DEW	Initial data supplied from *Bookeasy* enabled application of an algorithm designed by the researchers to inform a final set of visitor classes to then apply nights/room to the dataset.
Accommodation, incidental or direct economic expenses	*Bookeasy* data as provided by DEW and the Australian Tax Office 2019/11 Taxation Determination data	Assumed that up to two visitors would utilize one room each night, and multiplied by number of nights recorded for the trip. One additional room added for each additional two visitors in the total party. All Victorian visitors with greater than 4 h travel assumed to stay in a 'Tier-Two' town overnight, but beyond that first night 'Other Country Center' rates applied. All other origins assumed to stay overnight at a 'Country Center' town for travel duration. International visitors assumed to land in Adelaide, stay minimum one night in the city before undertaking their park or conservation site trip. Another night in Adelaide at City Australian Tax Office rate assumed before leaving the state at conclusion of trip.

selections given limited camping/accommodation options away from them.

With the origin and destination geometry established, Bing Maps' web-based distance matrix mapping tool (and customized web-map service requests for each visitor record) was used to estimate a travel distance in kilometer/time in minute values for each trip through batched calls and subsequent web scraping routines (see Appendix A for more detail). A comparison with Google Maps web services was also undertaken where we found strong result similarities (data not shown). Many South Australian protected area sites are in very remote parts of the state resulting in high relative travel expenditure (e.g., higher fuel and accommodation expenses), which must be taken into account when interpreting the final results. Ultimately, the original data included a reasonably full set of observations in these cases limiting requirements for extrapolation to address gaps. More important were issues related to the potential for double-counting of distances where multiple sites were visited in a single trip (~22,000 or 3% of total records), and the uncertainty around international travelers' exact origin and distances (~5–10% of total records). Unique booking numbers allowed capacity to calculate maximum distances for multiple trips, where highest distance divided by the total number of park or conservation sites visited formed the basis of the final contribution. For international visitor origin points, to maintain a conservative estimate we treated all international visitors as having arrived in South Australia by aeroplane into Adelaide. It was then assumed they would stay one night either side of their trip to protected area sites at the Adelaide Capital City charge rate (see Table 1 below). International visitor park visit secondary expenditure was then estimated using the same travel activity parameters.

Four databases were created to account separately for the (i) *Bookeasy*, (ii) credit card, (iii) Seal Bay, and (iv) Naracoorte Caves point of sale data sources, and later integrated into a single database. Total travel expenditure estimates are thus derived by combining the activities in each database into a single set of observations. The detail available from the *Bookeasy* database and icon site point of sale details for protected area sites in South Australia provided a relatively unique set of revealed preferences. Much of the potential bias in the literature discussion above associated with high-zero-value observations collected through visitor surveys was thus reduced and rigorous travel expenditure estimates from individual sites/regions were also possible due to the availability of individual protected area site data. Consequently, we do not have to infer or transfer values from one representative park to other parks across the network. Following the collation process, the complete dataset contained records of 643,823 park visitors from intra-state, interstate and international origins.

Estimation Parameters and Assumptions

The calculation of visitor travel expenditure involved four basic steps: (i) source all data for the origin and destination sites for each visitor, followed by data cleaning, transfer and loading into a single database; (ii) assign an individual x–y location parameter to each visit and account for distance traveled; (iii) assign the time class and calculate individual travel expenditures in the integrated database to update values; and (iv) calculate aggregate travel expenditure (based on mileage and accommodation) from protected areas to stratify by NPWS park/region/visitor origin/year. Travel activity expenditure captured in this study arose at four levels: park, region, state and national, enabling analysis and final reporting by individual site (e.g., Mount Remarkable National Park), relevant regional area (e.g., Yorke and Mid-North), for the South Australian economy, and finally for the larger Australian economy. Travel activities relevant to the analysis included distances traveled by car, vehicle expenses, accommodation expenses (where necessary on longer trips), and meals and incidentals per visitor. All of these values are derived from the Australian Tax Office's (ATO) 2019/11 travel determination data for 2018–19, available on the ATO website[3].

In some instances, the visitor's nationality was Australian but their origin was not from the mainland, and Bing Maps failed to return a distance or time (e.g., Christmas Island). In such cases it was assumed these visitors flew to Adelaide but additional accommodation expenditure either side of their trip was excluded to ensure a conservative travel expenditure estimate. All values used to estimate travel expenditure were based on 2018–19 rates where possible. The ATO rates used to complete the travel expenditure calculations appear in Table 2. Although the opportunity costs of time at the Australian minimum wage rate was evaluated as an additional expenditure item, consistent with some other studies it was decided not to include that expense in the final estimates.

Input–Output (I–O) Modeling

Regional economic impact models such as I–O assessments include several assumptions: constant returns to scale, unconstrained supply, fixed commodity and input structure which may be addressed using non-linear input–output models (Klijs et al., 2015), and homogenous sector outputs (Duffield et al. 2013). In this case, BDO's RISE v.6.04 I–O model was employed to estimate the total effect on the regional economies of South Australia resulting from direct changes in protected area visitation spending. The vector of final demand (Y) for products or services in each of the RISE sectors (1 to n) is calculated using matrix notation as:

$$X - AX = Y$$

where X is a vector of outputs for each sector (1 to n) in the model and A is a matrix of technical coefficients. Changes in employment and income in each defined regional economic area are derived from the given change in final demand as:

$$X = (1 - A)^{-1} Y$$

where I is an identity matrix. Effects on employment and income derived from the model based on an initial change in final demand include direct effects in the final demand tourism sector, indirect effects for businesses linked to the final demand sector (e.g., retail) through input purchases, and induced effects from expenditure in directly and indirectly affected sectors (e.g., transport). This set of equations is useful for estimating regional supported employment and gross regional product (GRP) values for tourism stimulus for protected area visits, which link well to the intention of the RISE model. The travel expenditure estimates in each regional area (e.g., Far North) provided input data for specific regional I–O model runs, and the means to then calculate the multiplier effect of that economic activity on individual Gross Regional Product and supported Full-time Employment outcomes. Together these values form the study results.

Results

In total, there were 643,823 recorded visits[4] to regional South Australian protected area and conservation reserve sites in 2018–19. As shown below (Table 3), total secondary contributions from tourism travel cost and regional economic impacts to the state's economy were AU$358.8 million. The Adelaide and Mt Lofty Ranges (metro parks) added further benefit, but are outside the regional area scope of the study, and thus are included only for indicative purposes.

The main reason for the pattern of regional economic contributions from travel costs is the distance (i.e., travel expenditure) involved in visiting remote protected areas in South Australia. The distribution and type of attractions at these sites may also play a part in drawing visitors to some

[3] Australian Tax Office's (ATO) 2019/11 travel determination data for 2018–19 available at https://www.ato.gov.au/law/view/document?docid=TXD/TD201911/NAT/ATO/00001.

[4] To clarify, recorded visits refer to the total number of people present in parks per day, totaled for the year. They do not represent discrete individuals.

Table 2 Travel cost expenditure rates (source: Australian Taxation Office 2021)

Example secondary expenditure	Rate applied (in AU$)
Vehicle travel costs (ATO)	$0.68 cents/kilometer
Adelaide accommodation	$157/night
Adelaide meals & incidentals	$133.75/day
Adelaide City full rate	$290.75
Tier-Two town rate	$152/night
Tier-Two meals & incidentals	$138.80/day
ATO Tier-Two full rate	$290.80
Other Country Center rate	$110/night
CC meals & incidentals	$121.15/day
ATO Country Center full rate	$231.15

regions where higher ecosystem benefits are generated. As previously stated, visitor data is poor for some highly accessed parks in the Mount Lofty Ranges and Limestone Coast regions because no booking/entry fees are required (e.g., Morialta Conservation Park). Since we are estimating secondary economic contributions the more distant the site the higher the cost/secondary economic benefits that will emerge from the analysis.

The majority of the travel expenditure was incurred on accommodation and incidentals such as food and beverages. Within South Australia, a total of AU$181.6 million was spent on accommodation and meals associated with visits to regional protected area sites in the conservation network, while associated travel expenditure contributed AU$66.7 million to the state economy (see Table 4 for individual park details).

This travel activity also contributed to the national economy, adding AU$68.4 million in secondary economic contributions to the states and territories outside South Australia as visitors traveled through them to get to South Australian regional protected area sites of interest. For an individual region, the analysis also showed which parks performed well and the specific contribution from sites in the network (see Fig. 2 for an example of Kangaroo Island parks). This helps to illustrate the substitute parks within a similar region, and how they may be interacting with other sites around them. Given that visitors can access similar protected area sites within a region with relative ease this analysis may help inform resource allocation decisions across the entire regional network.

Individual regional economic impact summaries were also possible via the RISE I–O model assessment. For the Kangaroo Island and Fleurieu region in 2018–19, as an example, the travel expenditure stimulus of AU$109.7 million resulted in multiplier impacts totaling AU$56.3 million in additional gross regional product and supported 616 jobs in the regional economy, split between initial and flow-on impacts (Table 5).

Table 3 Secondary contributions by region

SA Regional use values	Travel expenditure ($)	I–O multiplier	Total Secondary Impacts
Eyre and Far West	$37.6 M	$17.4 M	$55.0 M
Flinders and Outback	$34.4 M	$14.3 M	$48.7 M
Kangaroo Island	$109.7 M	$56.3 M	$166.0 M
Limestone Coast	$23.8 M	$11.6 M	$35.4 M
Riverland and Murray Lands	$3.8 M	$1.8 M	$5.6 M
Yorke and Mid North	$33.4 M	$14.8 M	$48.2 M
Total Regions	$242.5 M	$116.3 M	$358.8 M
Adelaide and Mount Lofty Ranges	$5.8 M	$2.9 M	$8.7 M
Whole indicative SA contribution	$248.3 M	$119.2 M	$367.5 M

Visitor Origins

As shown in Fig. 3 below the main secondary contributions came from South Australian (AU$57.5 million) and international visitors (AU$64.0 million) due to higher accommodation expenditure. The willingness of South Australians to engage with protected areas and conservation sites is positive, as is the significant value they place on these sites for tourism ecosystem services and other purposes. Close neighboring states such as Victoria (VIC) and New South Wales (NSW) contributed the next highest values, followed by visitors from Queensland (QLD) and Western Australia (WA). The lowest contributions were derived from Australian Capital Territory (ACT), Tasmanian (TAS) and Northern Territory (NT) visitors which appear to be relatively negligible but combined amount to AU$7.17 million —or ~5.6% of the interstate contribution (AU$126.8 million).

We offer some further analysis of the key South Australian protected area sites below. Figure 4 shows the movement of visitors by origin, and their respective major regional destinations.

In this case, we include some indicative results for parks within the Adelaide and Mount Lofty Region (AMLR), where visitors predominately originate from South Australia. One key site within AMLR, Cleland Wildlife Park, is demonstrative of a key point of difference between the primary and secondary values of economic contributions. Our weighted (and assumption-based) estimates for this site falls to very low secondary travel expenditure levels, in contrast with its high concomitant primary revenue values (Fig. 5). This is due to the relatively short travel distances involved in visiting Cleland Wildlife Park which is close to the State's primary population center, Adelaide. As a consequence, our expenditure aggregation steps heavily

Table 4 Individual site travel expenditure by South Australia/National contribution, 2018–19

	Values				
Park	Accommodation in SA	Distances in SA	Accommodation National	Distances National	Visitors
Acraman Creek	$107,540	$56,779	$50,761	$64,016	199
Agent Desert Parks	$440,690	$222,367	$218,323	$263,635	232
Beachport	$489,410	$352,092	$137,317	$393,032	1084
Belair	$181,941	$88,856	$93,085	$119,185	14,701
Bool Lagoon Game Reserve	$520,254	$336,068	$184,186	$379,896	1136
Canunda	$1,114,900	$856,562	$258,339	$950,718	2909
Cape Borda	$1,577,651	$763,193	$814,458	$922,944	3359
Cape Gantheaume	$336,817	$230,298	$106,519	$285,513	765
Cape Willoughby	$2,341,469	$1,164,434	$1,177,035	$1,458,745	6,809
Chowilla Game Reserve	$375,685	$254,304	$121,381	$261,459	1453
Cleland	$177,643	$113,257	$64,386	$135,458	4026
Coffin Bay	$15,310,546	$9,012,407	$6,298,139	$10,204,158	23,230
Coorong	$2,611,403	$1,496,724	$1,114,680	$1,796,603	9819
Danggali Conservation Park	$61,560	$42,925	$18,635	$49,461	102
Deep Creek	$3,569,284	$1,469,614	$2,099,670	$1,775,101	37,000
Dhilba Guuranda-Innes	$23,702,458	$13,936,354	$9,766,104	$15,012,501	54,319
Dutchmans’ Stern	$29,836	$17,680	$12,157	$18,176	118
Eyre Peninsula	$163,812	$75,102	$88,710	$77,880	228
Fleurieu Peninsula	$2212	$-	$2212	$-	62
Flinders Chase	$58,069,951	$50,839,237	$7,230,714	$51,707,022	118,771
Fowlers Bay	$456,862	$278,216	$178,645	$316,809	411
Gawler Ranges	$2,528,671	$1,439,491	$1,089,181	$1,640,917	3060
Ikara-Flinders Ranges	$25,184,410	$14,345,421	$10,838,989	$16,606,387	36,169
Innamincka Regional Reserve	$850,243	$519,330	$330,913	$601,461	1084
Kangaroo Island Wilderness Trail	$1,051,806	$744,439	$307,366	$835,376	2063
Karte Conservation Park	$17,804	$13,446	$4,358	$13,446	52
Kati Thanda-Lake Eyre	$1,348,506	$809,594	$538,912	$947,369	1337
Lashmar Conservation Park	$514,042	$321,597	$192,446	$383,838	1556
Laura Bay Conservation Park	$143,250	$82,238	$61,012	$100,889	132
Lincoln National Park	$14,783,886	$8,726,447	$6,057,440	$9,951,050	27,406
Little Dip Conservation Park	$1,500,038	$1,073,503	$426,535	$1,168,099	3725
Loch Luna and Moorook	$372,791	$179,126	$193,665	$186,654	2817
Malkumba-Coongie Lakes	$343,323	$223,605	$119,718	$262,988	486
Memory Cove	$1,605,719	$912,538	$693,182	$1,043,397	2345
Morgan Conservation Park	$167,241	$72,113	$95,128	$89,899	1253
Mount Remarkable	$9,614,676	$5,883,768	$3,730,908	$6,617,346	22,979
Murray River	$1,500,774	$961,007	$539,767	$1,055,878	6867
Naracoorte Caves	$10,913,987	$8,253,797	$2,660,190	$10,527,245	55,312
Newland Head	$467,141	$241,264	$225,877	$288,725	3810
Ngarkat	$1,224,151	$873,706	$350,446	$889,071	4525
Nullarbor	$180,662	$100,578	$80,084	$115,035	125
Onkaparinga River	$981,371	$635,642	$345,729	$779,874	4754
Para Wirra Conservation Park	$376,964	$180,082	$196,882	$220,572	10,465
Piccaninnie Ponds	$875,551	$646,104	$229,447	$685,476	2763
Point Bell Conservation Park	$5171	$2542	$2629	$3058	4
Seal Bay Conservation Park	$41,616,000	$40,386,375	$1,229,625	$45,846,369	122,234

Table 4 (continued)

Park	Values				
	Accommodation in SA	Distances in SA	Accommodation National	Distances National	Visitors
Tallaringa Conservation Park	$1,050,267	$531,524	$518,743	$617,910	812
Tantanoola Caves	$5,739,718	$4,777,616	$962,102	$5,408,373	17,492
Tolderol Game Reserve	$19,913	$10,474	$9,439	$13,443	221
Vulkathunha-Gammon Ranges	$842,680	$501,715	$340,965	$562,573	1214
Wabma Kadarbu Mound Springs	$50,482	$30,433	$20,049	$35,493	69
Wahgunyah	$161,546	$88,185	$73,361	$98,108	176
Witjira	$4,245,939	$2,372,811	$1,873,128	$2,637,240	2900
Wittelbee	$431,129	$263,758	$167,370	$322,332	378
Yellabinna	$722,255	$378,652	$343,603	$402,343	970
Yumbarra	$1,025,675	$556,258	$469,417	$598,726	1491
Kelly Hill	$4,163,888	$2,811,709	$1,352,180	$3,884,245	20,043
Grand Total	**$181,557,356**	**$66,706,240**	**$201,633,517**	**$115,049,489**	**643,823**

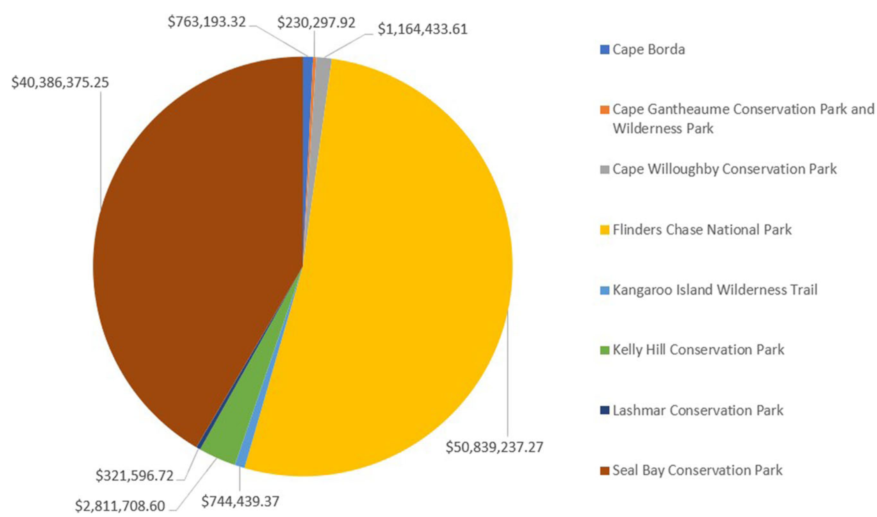

Fig. 2 Regional breakdown for all parks in the Kangaroo Island area

Table 5 Kangaroo island & fleurieu region I–O impact results

Additional expenditure	Secondary economic impact
	$109.7 M
Impact on Gross Regional Product	
Initial	$41.9 M
Flow-on	$14.4 M
Total	$56.3 M
Impact on Employment	
Initial	474.88 FTE
Flow-on	141.24 FTE
Total	**616.12 FTE**

discounted the associated expenditure of visiting Cleland Wildlife Park, and the economic contribution reflected low travel expenditure.

In total, these six icon sites contributed around 43% of the total secondary travel expenditure attributed to protected area tourism ecosystem benefits (i.e., of the AU$358.8 million). Once again, this result is important to reflect on as any assessment of the economic value of South Australian protected area sites and their management needs to take account of this difference in considering where value in the network is generated, and assessments of primary benefits alone (i.e., AU$15.42 million) may lead to a skewed perception. The big data observations behind these results provided useful and spatially comprehensive outcomes that were of significant interest to DEW and NPWS.

Discussion

We highlight the large visitor flows and economic benefits of visitors to the network of South Australian regional

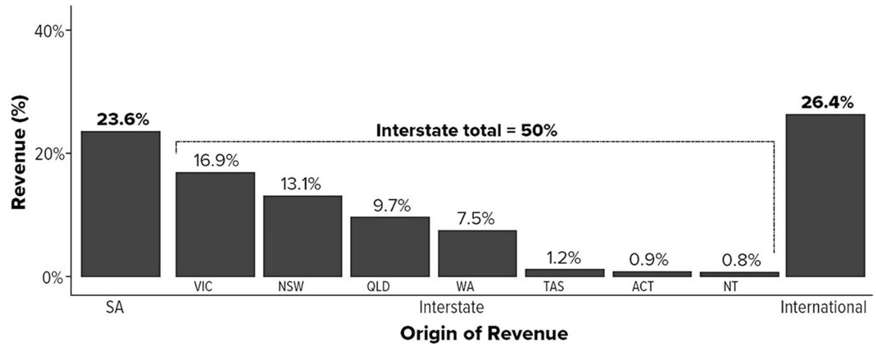

Fig. 3 Main sources of primary and secondary contribution by visitor origin

protected areas. We also stress that the values reported here represent potential underestimates of the true indirect use values for that network based on conservative estimations and incomplete information. For example, as we have not incorporated any non-use or co-benefit values (e.g., well-being or reduced healthcare costs), the figures are an underestimate of the true total economic welfare. Equally, as we cannot categorically state that all of the travel expenditure incurred was associated only with a visit to protected area sites the values reported may include over-estimates of the true use significance to visitors for some trips. That said, we were at least able to provide a baseline—if not final—expenditure estimate for the 2018–19 period. Yet, while we have estimated a conservative value for secondary tourism ecosystem benefits, we remain uncertain as to the drivers of that activity. Visitors are obviously attracted to the state's protected areas but more work is needed to understand what amenity benefits or site-specific utility motivated the spending reported here; for example, as provided by Heagney et al. (2018) for New South Wales national parks. Further analysis will add longer-term clarity to the picture emerging from this study for management purposes and prioritizing future conservation works.

However, of unique significance, our analysis of the total secondary economic contributions from South Australian protected areas ranged from very high (e.g., national focus) to more granular (e.g., individual park case study) levels. This provides NPWS managers with some assessment of nature-based tourism demand created by their conservation network, better positions them for discussions around how protected area sites create ecosystem benefits at different levels for the South Australian/Australian public, and informs management actions based on economic efficiency grounds—among other assessment criteria where accounting/budgetary methods underestimate the worth of conservation sites (Haefele et al. 2016a; Richardson et al. 2018).

Implications of the Research

This combined travel expenditure based on big data and I–O modeling study is also an innovative approach. By way of comparison, other protected area tourism and recreation ecosystem benefit valuation studies commonly use survey data collection methods from a random sample of the total population, which can result in difficult to analyse data from high zero-inflated responses because only a portion of respondents will have accessed a site. In this study, all observations are positive thereby avoiding zero-inflated responses and providing more rigorous—if not completely accurate—revealed preferences for use values of South Australian protected areas. Further, the data has high coverage across all key regional conservation sites (not including the Adelaide Metro Parks). This avoids the use of methods which estimate economic activity and multiplier benefits from a few data rich sites and the need to rely heavily on 'benefit transfer' methods or econometric aggregation estimation methods to apportion values for unstudied sites; though we were forced to extrapolate for a significant but proportionally small set of sites in this large network. Benefit transfer/econometric modeling approaches are commonly adopted due to cost/time pressures on data collection, but can lead to inflated value estimates which may only become apparent after repeated studies in the same location. In our study, using big data we have been able to collect, analyse and interpret information for every key visitor regional site in the DEW/NPWS-managed network with respect to both travel expenditure and multiplier impact values, thereby avoiding the need to scale up and transfer/aggregate values on the basis of assumptions about site similarity. The results represent appropriately conservative contribution estimations based on the methods used, data analyzed, and assumptions made explicit in the methods.

This work provided confidence to park management agencies (DEW/NPWS) and capacity to develop narratives around the contribution of protected areas and reserves to regional communities and their economies. Regional communities benefit from supported jobs and business sales created by site visitation, while visitors benefit from the conservation, recreation and health benefits provided by nature-based tourism (Richardson et al. 2018)—a value that warrants further investigation. As an extension to this research, a more complete estimate of economic benefits (e.g., total economic value estimates)

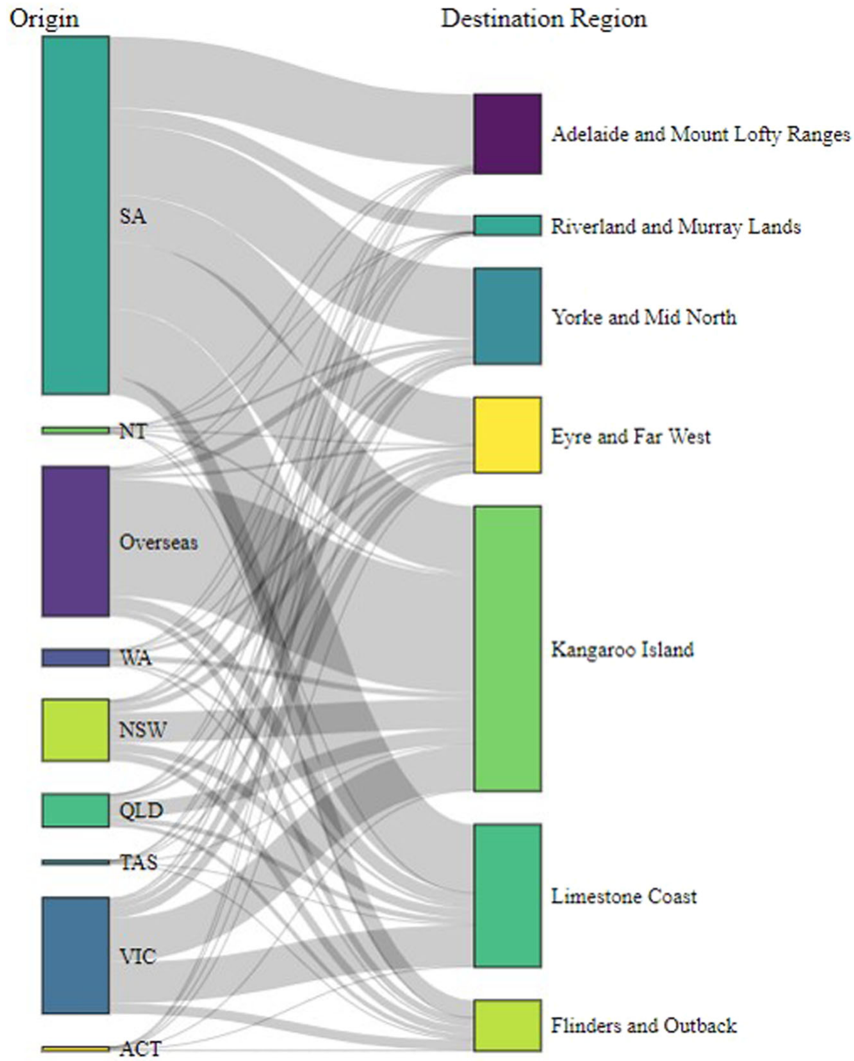

Fig. 4 Visitor flows between origin and destination points 2018–19

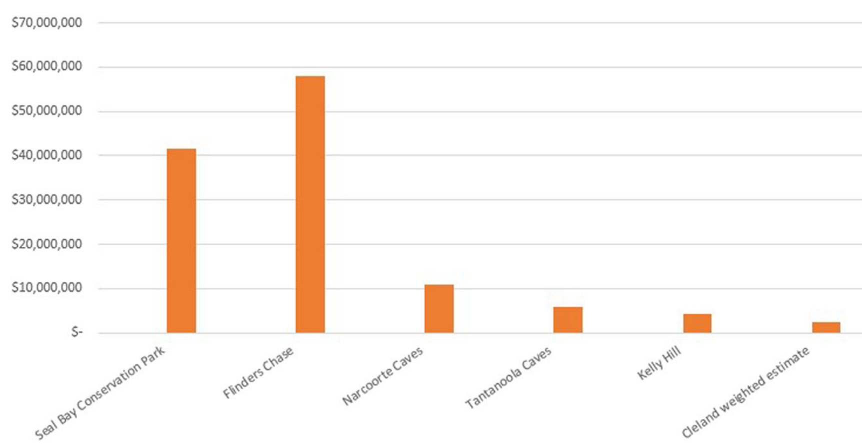

Fig. 5 Secondary economic contributions for key icon national park sites

could better position park management agencies to advocate for their mission with evidence-based support for the significant value created by parks for citizens and visitors, in addition to the positive regional economic activity generated from national park visitation and operations. That said, economic estimates of value remain only a single tool in the wider array of value estimates needed to inform final management and investment choices. As stated elsewhere in this paper, the value of bequest and existence conservation benefits are also important, requiring additional analysis which is planned beyond this study.

Refinement of visitor use big data is also necessary to ensure the utility of visitor information to inform and support public investment decisions. General weaknesses in the data for this analysis included: (i) some internal rigor issues (e.g., accommodation bookings with no associated visitor numbers, lack of error checking at data entry stage, and itineraries spanning multiple years e.g., 2017–2019), (ii) absence of reliable data from high visitation/non-icon sites in the Adelaide and Mount Lofty Ranges areas (e.g., Morialta Conservation Park), (iii) incomplete data from key icon sites (e.g., Naracoorte Caves), (iv) lack of data for validating assumptions about behavior of international travelers, and (v) lack of breakdown of visitation behavior. How to address these issues should also be the subject of future analysis.

Conclusions

This study used a big data approach to analyse protected area tourist visitation ecosystem benefits to address a range of issues that have been debated in previous travel cost method and input–output modeling studies. For the South Australian protected area network—in total, an area that exceeds the footprint of some European counties—we find that visitation returned >AU$15 million in direct revenue over the 2018–19 financial period, while the combined secondary impact of visitor travel costs and regional economic impacts were estimated at AU $358.8 million to the South Australian economy for the same period. Regional protected area sites were responsible for around 66% of those secondary benefits, with parks on Kangaroo Island such as Seal Bay and Flinders Chase providing significant value. These sites are attractive to South Australians and international visitors alike, but following major destruction during the bushfires of 2019–20 visitor numbers have dropped away. Hence, public funding allocations toward rebuilding and refurbishment will be key to ensuring the future success of, and continued economic contributions from, those national parks.

Regions also clearly rely on the conservation reserve network to attract secondary economic benefits from tourism and recreation, with some regions deriving greater benefit than others. This impact mainly relates to economic sectors associated with accommodation and food and beverage services. These results indicate the positive economic impacts of protected area tourism, where other benefits (e.g., improved fitness and wellbeing having a cost reduction impact in the healthcare sector) could also be explored. We will investigate these values and benefits in future research.

Compliance with Ethical Standards

Conflict of interest The authors declare no competing interests.

Appendix A: Distance calculation codes

Available at: https://www.microsoft.com/en-us/maps/choose-your-bing-maps-api

Bing Maps (226 km)


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–<TraceId>
  25f45a201ccf452dbe886def788879ec|HK00000C07|0.0.0.0|HK00000A3D
 </TraceId>
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  –<ResourceSet>
     <EstimatedTotal>1</EstimatedTotal>
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             <Longitude>138.338749</Longitude>
           </Coordinate>
         </Origins>
        –<Destinations>
          –<Coordinate>
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         </Destinations>
        –<Results>
          –<Distance>
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             <DestinationIndex>0</DestinationIndex>
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             <TotalWalkDuration>0</TotalWalkDuration>
```


Google Maps (226 km)


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–<DistanceMatrixResponse>
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   <destination_address>Pondalowie Bay Rd, Inneston SA 5577, Australia</destination_address>
  –<row>
    –<element>
       <status>OK</status>
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         <text>2 hours 40 mins</text>
       </duration>
      –<distance>
         <value>226444</value>
         <text>226 km</text>
       </distance>
     </element>
   </row>
 </DistanceMatrixResponse>
```


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