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RESEARCH ARTICLE

From parachuting to partnership: Fostering collaborative research in protected areas

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Abstract

1. Research in protected areas (PAs) is often dominated by scientists from outside the conservation agencies managing them. This can potentially lead to misalignment with local needs, insensitivity to the local context and a lack of investment in and use of local expertise. These issues often arise when international researchers work in another country without local engagement (known as 'parachute science'). Despite PAs being key end users of actionable science, there is limited understanding of the prevalence and impact of parachute science in these areas.
2. Here, we investigate parachute versus collaborative research in two national parks in the Global South (Kruger National Park, South Africa; Nahuel Huapi National Park, Argentina) and one park from a developed economy (Kakadu National Park, Australia). To explore the prevalence, risks, benefits and complexities of research practices, we analyse the patterns of authorship, funding and acknowledgement in a random sample of peer-reviewed papers from research conducted in these parks.
3. Our findings show a higher incidence of potential parachute science in Kruger National Park (18% of papers with only out-of-country authors) compared to Nahuel Huapi (4%) and Kakadu (2%) national parks. However, the occurrence of internationally collaborative research (national and international authors) was double in Global South parks (35%–38%) than in the Australian park (18%).
4. The study illustrates the potential benefits of international collaboration for PAs, including increased research productivity, expanded funding sources and possibly

higher impact and visibility of published studies. PAs in developed countries may have fewer opportunities to obtain those benefits.

5. Most papers, even those with in-country authors, lacked authors affiliated with the agency managing the PA and often failed to even acknowledge these agencies. This suggests the potential for a different form of parachute science (which we term 'park parachuting') in which lack of local involvement may hamper integration of research with management.
6. *Synthesis and applications*: Establishing conditions that foster collaboration between national and international researchers, and between PA agency staff and external researchers (regardless of their nationality), would enable parks to better serve as catalysts for research collaboration. This collaborative approach can facilitate access to additional funding, enhance research capacity, increase research productivity and amplify research impact.

KEYWORDS
absorptive capacity, helicopter science, inclusive science and conservation, knowledge exchange, national park science, research impact, science–policy interface, scientific collaboration

1 | INTRODUCTION

Science has an important role to play in protected area (PA) management (Machlis & McNutt, 2015). While some PAs benefit from in-house scientists (i.e. scientists within the PA management agencies) facilitating the science–management interface (Roux et al., 2006, 2015), many lack this support. Consequently, PA managers face challenges in generating, facilitating and integrating relevant research (van Wilgen et al., 2016). Even with agency scientists, internal capacities often fall short of addressing key knowledge gaps (van Wilgen et al., 2016), leading to external scientists (as opposed to agency scientists) dominating PA research (Smit et al., 2017).

External scientists conducting research in PAs are often from universities, non-governmental organizations (NGOs) and other research institutes. A concern with research being conducted by external researchers is that their work may not align with local needs, potentially limiting policy- and management-relevant outcomes (Fazey et al., 2005; Fernández, 2016; Rayadin & Buřivalová, 2022). In addition, such research may not be contextualized or sensitive to the local situation and may fail to invest in, fully partner with or recognize local capacity, expertise and relevant social and governance structures (De Vos & Schwartz, 2022). In particular, concerns have been expressed about international researchers working in another country without properly engaging with the local scientists and communities, termed 'helicopter' or 'parachute' science (Bagla, 1997).

Parachute science often occurs when well-resourced scientists from the Global North (developed economies) conduct research in resource-poor countries from the Global South (developing economies) without co-development or input from local scientists and communities, resulting in limited sharing of knowledge and benefits, or even undermining local research efforts and increasing dependency (De Vos, 2020; Rayadin & Buřivalová, 2022). Although concerns about inclusivity in research were recognized a long time ago (Bagla, 1997), the prevalence of and risks associated with parachute science and the ways in which those risks can be addressed are only starting to gain broader recognition in the research community.

Research on parachute science spans many fields, including conservation (Miller et al., 2023), ecology, biology, geoscience (Minasny et al., 2020) and marine science (Ahmadia et al., 2021; Stefanoudis et al., 2021). Concerns have also been raised in archaeology (Thondhlana et al., 2022) and palaeontology (Cisneros et al., 2022). Fortunately, conservation scientists are increasingly aware of such practices and attempting to address them (De Vos, 2022), with calls for improved collaborative approaches (De Vos & Schwartz, 2022).

The prevalence of parachute science in different subject fields, regions/countries or journals has been highlighted by studies that emphasize the underrepresentation of local authors in publications (Hazlett et al., 2020; Mabele et al., 2023; North et al., 2020; Stefanoudis et al., 2021). Although local conservation organizations are supposed to be one of the key end users of actionable conservation science (Gerber et al., 2020; Smit et al., 2017), the growing literature on parachute science is largely written from an academic perspective, and with an emphasis on what academics, universities and journals should do to curb this practice (e.g. Nuñez et al., 2019; Pettorelli et al., 2021; Stefanoudis et al., 2021). This is valuable, but leaves a key gap in understanding the

experiences and perspectives of local conservation management agencies. Furthermore, risks associated with parachute science practices, including misalignment between externally conducted research and local research needs, and limited opportunities for co-learning, can occur whenever external scientists, irrespective of their nationalities, neglect meaningful engagement with local needs and expertise within the relevant conservation management agencies.

This study aims to quantify collaboration between international researchers, national scientists and PA staff. We compare evidence of potential parachute science, international collaboration and research conducted exclusively by within-country scientists in three iconic and well-researched national parks across continents. We include two iconic parks from countries classified as upper middle income by the World Bank where parachute science practices may be more likely (Kruger National Park, South Africa and Nahuel Huapi National Park, Argentina) and one national park in a country classified as high income with lower expected risk of parachute science (Kakadu National Park, Australia; World Bank, 2022). Reflecting those differences in income and economic development levels, we will refer to Argentina and South Africa as Global South countries and Australia as Global North for the purposes of this study. We examine research funding, citation rates and journal impact factor patterns in globally collaborative and within-country authored papers, contrasting them with potential parachute science practices (only out-of-country, 'international' authors). We further assess the involvement and acknowledgement of local conservation agencies in research outputs produced by external scientists. This evaluation explores another form of potential parachute science, where both within-country and international researchers may fail to involve and recognize the contributions of park agencies (we term this 'park parachuting'). We leverage our case study results to propose broad strategies to enhance collaboration across nationality and academia–practitioner interfaces.

2 | MATERIALS AND METHODS

While previous studies have taken a national or continental scale approach to understanding parachute science, our study employs a case study approach by focusing on iconic national parks on different continents: Kruger National Park (South Africa) and Nahuel Huapi National Park (Argentina) from the Global South; and Kakadu National Park (Australia) from the Global North; hereafter, these parks are referred to as Kruger, Nahuel Huapi and Kakadu, respectively. Based on a Clarivate Web of Science search (2010–2020), these parks emerged as the terrestrial national parks with the most publications in their respective countries, making them ideal for examining the prevalence of parachute versus internationally collaborative science.

A general background description of each of the three study parks, the focus of their dedicated research staff and the process followed by external scientists to register research projects in the parks are provided in Appendix S1 in Supporting Information.

2.1 | Search strategy and inclusion criteria

Literature searches were conducted via the Clarivate Web of Science search facility using the 'all databases' (which includes the Web of Science Core Collection, SciELO, BIOSIS Previews and others) and 'all editions' options. The search strings consisted of the name of the park (["Kruger National Park"]; ["Nahuel Huapi National Park" OR "Parque Nacional Nahuel Huapi" OR "Lake Nahuel Huapi" OR "Lago Nahuel Huapi"]; ["Kakadu National Park"]) and we selected the 'topic' as search field. According to Clarivate, the 'topic' field searches for the specified search terms in the title, abstract or keywords, and therefore will miss papers using the park name in the main text only. We restricted the search to journal articles published between 2010 and 2020. Each article was assigned a random number. We then assessed the relevant papers in ascending order until we reached a maximum of 100 relevant papers. Although parachute science practices appear to be more prevalent in publications in English than in those in other languages (Miller et al., 2023), there is a growing awareness of the detrimental effects of ignoring non-English publications (Amano et al., 2021). Therefore, we included papers for Nahuel Huapi published in Spanish (13% of our random sample).

To be included, studies needed to be based on research within the park, have made use of data or specimens collected from the park or have used the park as a case study in descriptive studies. Articles were also included if the park formed a central component in social–ecological studies (e.g. community relationships, human–wildlife conflict or livestock/wildlife diseases around parks). Articles making a passing reference to a park, or referencing research or other papers from a park, were excluded. The paper searching and sampling framework is summarized in Figure S1 (Appendix S2).

2.2 | Data extraction and analysis

Metadata for all authors were extracted, including author rank (primary or co-author) and their primary institutional affiliation. Author affiliations were coded based on (i) nationality (country of all authors' primary affiliation) and (ii) managing agency (whether or not an author was affiliated with the respective national park agency).

In addition, the funding sources for the research were extracted; funding sources were most commonly listed within the acknowledgements section (Cronin, 2001; Mejia & Kajikawa, 2018), or as a separate funding statement. We classified the funding as originating from the country where the national park was located ('national funding'), or from another country ('international funding'). References to non-financial contributions to the research by the park agency, such as logistical support or field assistance, mentioned in the acknowledgements section were also extracted. We did not consider a mention

of a park-issued permit as reflecting genuine acknowledgement of engagement, but rather as an acknowledgement of compliance with conditions required to gain access to the parks.

To estimate the academic ranking of the journal where research was published and thus the potential academic visibility and reach of a study, we used the Clarivate journal impact factor (2021). In cases where no impact factor was assigned, we recorded a zero. We also calculated the average number of citations per year as a metric of the paper's uptake and impact in the literature. We calculated this by dividing the total number of citations recorded in Clarivate Web of Science by the number of years since publication up to 2023.

To evaluate how collaborative the research was, we calculated the mean number of authors and diversity of author affiliations per paper for each park. We distinguished papers listing only national authors (indicating a potential lack of international perspectives), both national and international authors (potentially inclusive of cross-national perspectives) or only international authors (suggesting potential parachute science). Based on this, we estimated for each park the proportion of papers in each category. In addition, we noted whether the papers with a combination of national and international authors were led (first authored) by a within-country author or an international author (using authorship order as proxy for research leadership; e.g. Miller et al., 2023). We did not interpret the last author as a leadership role, as this is not a universal convention.

To gauge collaboration with park staff, we classified studies according to whether personnel from the park management agency were the primary author, a co-author or unrepresented. For those papers in which the local park agency was unrepresented in the authorship, we calculated the proportion of studies where the park agency (including any of its staff or the traditional owners in the case of Kakadu) was explicitly acknowledged in the paper.

We estimated the material support for research by calculating the proportion of research funded by national versus international funding sources for each park, also noting the proportion of studies that did not report any funding sources.

We used the non-parametric Kruskal–Wallis test to assess the variation in impact factor and annual citation based on authorship composition and funding sources for each park. Following that test, we performed the Conover–Iman test (with Bonferroni correction) for post hoc pairwise comparisons to identify which specific groups differed from each other. We conducted all statistical analyses using R version 4.3.1 on the online platform Posit Cloud (https://posit.cloud), through the R packages *FSA* (Ogle et al., 2023) and *conover.test* (Dinno, 2024).

3 | RESULTS

3.1 | Research output

Mean and median 2021 Clarivate impact factors and annual citations per paper were comparable between Kruger and Kakadu, with lower values recorded for Nahuel Huapi (Table 1).

3.2 | Research authorship

Research across all parks was collaborative, averaging four to five authors per paper. Few papers lacked national authorship for Kakadu (2%) and Nahuel Huapi (4%), with higher levels of exclusively international authorship for Kruger (18%) (Table 1). Collaboration between national and international authors was more prevalent in Kruger and Nahuel Huapi (35%–38%), around double what was observed in Kakadu (18%). National authors mostly led internationally collaborative papers, especially in Kakadu and Nahuel Huapi, where Australian and Argentine researchers, respectively, were primary authors on considerably more papers than those with international primary authors (Table 1). Kruger had roughly equal national and international primary authorship in papers with both South African and international co-authors. Papers from Kruger involved more unique nationalities ($n = 18$), relative to Nahuel Huapi ($n = 12$) and Kakadu ($n = 8$). The USA emerged as the leading international partner across all three parks. In Kakadu, 8 of 19 papers with international authors involved researchers from the USA, compared to 16 of 39 for Nahuel Huapi, and 35 of 56 for Kruger.

External authors, not affiliated with the park, dominated publications across all three parks. Management agency involvement in publications varied, with 32% (Kruger), 15% (Nahuel Huapi) and 10% (Kakadu) of papers, respectively, having authors from the management agency (Table 1). Approximately 8%–10% of papers from Kruger and Nahuel Huapi were led by the park management agency, compared to none in Kakadu. The managing agency and/or its staff were neither included as authors nor mentioned in the acknowledgement section in 26% and 61% of the papers from Kruger and Nahuel Huapi, respectively. For Kakadu, 32% of the papers did not include park staff as co-author or acknowledge the park agency and/or the traditional owners (joint management partners).

3.3 | Research funding

Kakadu seemed to benefit the least from international funding (8% of papers), compared to Kruger (60%) and Nahuel Huapi (33%) (Table 1). For papers with both national and international author affiliations, only 30% of papers from Kakadu included international funding or co-funding, while Kruger and Nahuel Huapi had international funding or co-funding for 87% and 60% of those papers, respectively (Table 1).

3.4 | Journal impact factor and citation rate

The median impact factor and annual citation rate for papers from Kruger and Nahuel Huapi were in some cases higher when international authors were involved (Figure 1; Table 2). The origin of authors did not significantly influence annual article citation rates or journal impact factor for Kakadu (Figure 1; Table 2). Similarly, international funding and/or joint national and international funding were in a few cases associated with higher average Clarivate impact factors and annual citation rates for Kruger and Nahuel Huapi (Figure 2; Table 3).

TABLE 1 Bibliometric information for papers from Kruger, Kakadu and Nahuel Huapi National Parks.

	Kruger NP	Nahuel Huapi NP	Kakadu NP
Sample size, impact factor and annual citations			
Total number of papers included	100 (99 in journals with a 2021 Clarivate Impact Factor)	100 (83 in journals with a 2021 Clarivate Impact Factor)	96 (83 in journals with a 2021 Clarivate Impact Factor)
Average (median) 2021 Clarivate Impact Factor	3.71 (3.38)	2.81 (2.26)	3.89 (2.36)
Average (median) annual citations	3.65 (2.67)	2.19 (1.68)	3.55 (2.57)
General authorship statistics			
Average (median) number of authors per paper	4.71 (4)	4.12 (4)	4.60 (4)
Average (median) number of national (within-country) authors per paper	3.01 (3)	3.30 (3)	4.33 (3.50)
Average (median) number of international (out-of-country) authors per paper	1.70 (1)	0.84 (0)	0.26 (0)
Collaboration across nationalities			
Only national authorship	44%	61%	80%
Only international authorship	18%	4%	2%
National and international co-authorship: first author national	18%	33%	13%
National and international co-authorship: first author international	20%	2%	5%
Involvement of managing agency			
Principle authorship by managing agency	8%	10%	0%
Co-authorship by managing agency	24%	5%	10%
No authorship by managing agency	68%	85%	90%
No authorship of managing agency: Managing agency (or staff) mentioned in acknowledgements	42%	24%	58% (park authority and/or traditional owners acknowledged)
No authorship of managing agency: Managing agency (or staff) not mentioned in acknowledgements	26%	61%	32% (neither park agency nor traditional owners acknowledged)
Funding (all papers)			
No funding declared	10%	19%	27%
Only national funding declared	30%	48%	65%
Only international funding declared	36%	11%	4%
Both national and international funding declared	24%	22%	4%
Funding of subset of papers with both national and international authorship			
No funding declared	5%	6%	0%
Only national funding declared	8%	34%	70%
Only international funding declared	45%	17%	12%
Both national and international funding declared	42%	43%	18%

4 | DISCUSSION

Parachute science, characterized by inadequate involvement of local scientists, organizations and communities, can reduce the value and relevance of research and therefore its uptake into local knowledge and practice (De Vos, 2020; Rayadin & Buřivalová, 2022). Parachute science has not, to our knowledge, been explored before from a protected area (PA) management perspective. Our study starts to address that gap by providing—through an analysis of published literature—a nuanced assessment of the risks of parachute science relative to the potential benefits of collaboration, and the practices that may facilitate management-relevant research.

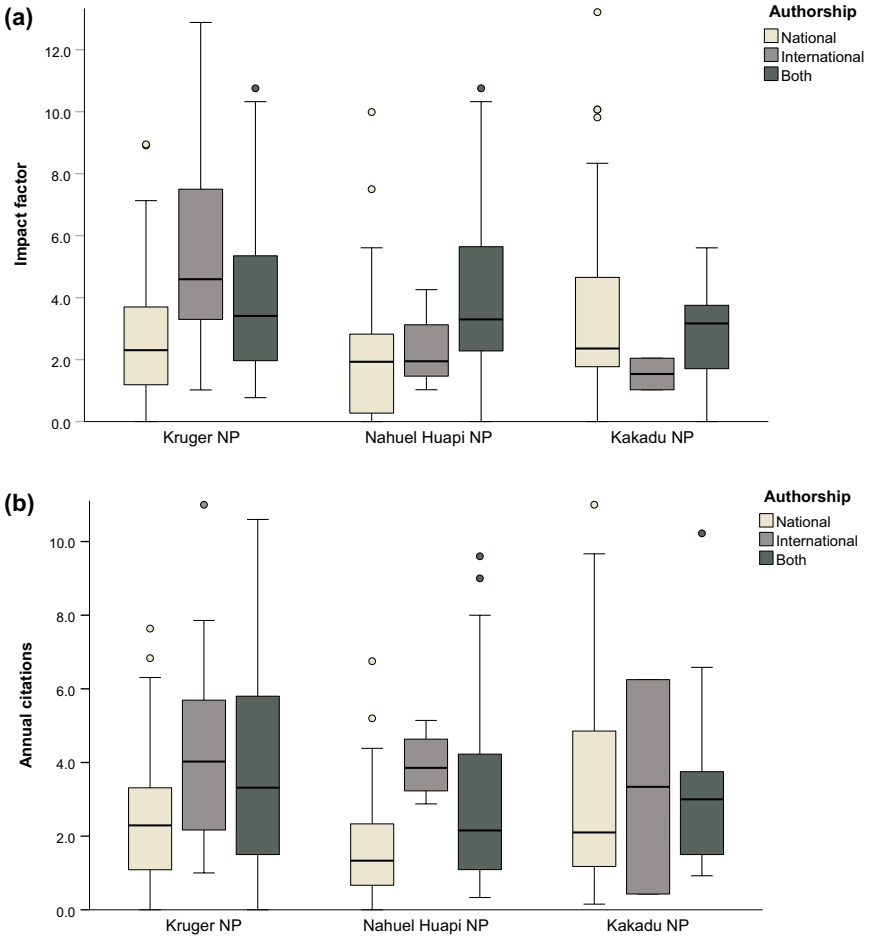

FIGURE 1 Clarivate impact factors (a) and annual citation rates (b) for papers with author teams from the country of origin (national), international or a combination of both national and international authors across three national parks. Black line indicates the median value, the box indicates the interquartile range, whiskers indicate minimum and maximum excluding outliers, and the circles are outliers >1.5 x interquartile range. See Table 2 for test statistics.

TABLE 2 Test statistics for differences between the impact factor and annual citation rate based on authorship of studies conducted across the case study parks.

Impact factor				Annual citations			
Kruger National Park							
$H=9.330$; $n=100$; df = 2; $p=0.009$				$H=5.519$; $n=100$; df = 2; $p=0.063$			
	National	International	Both		National	International	Both
National	–			National	–		
International	0.007	–		International	0.088	–	
Both	0.291	0.245	–	Both	0.297	1	–
Nahuel Huapi National Park							
$H=13.037$; $n=100$; df = 2; $p=0.001$				$H=14.558$; $n=100$; df = 2; $p=0.001$			
National	–			National	–		
International[a]	1	–		International[a]	0.010	–	
Both	0.001	0.607	–	Both	0.006	0.297	–
Kakadu National Park							
$H=1.398$; $n=96$; df = 2; $p=0.497$				$H=0.700$; $n=96$; df = 2; $p=0.705$			
National	–			National	–		
International[a]	0.728	–		International[a]	1	–	
Both	1	0.790	–	Both	1	1	–

Note: The Kruskal–Wallis test statistic (H) and the associated p-value are provided at the top of each matrix, with the Bonferroni adjusted p-values of the Conover–Iman pairwise comparisons appearing within the matrices (dark grey $p<0.05$; light grey $p<0.10$).

[a]Indicates sample sizes of $n \leq 5$.

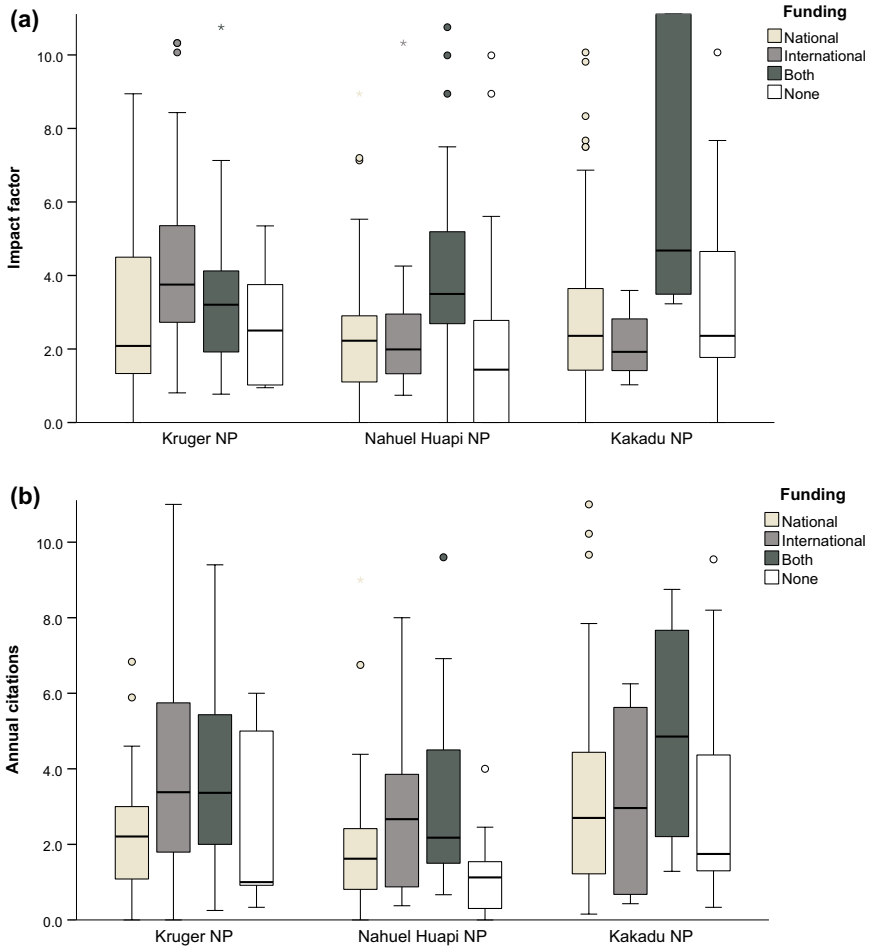

FIGURE 2 Clarivate impact factors (a) and annual citation rate (b) for papers across three national parks declaring national or international funding, or funding from both national and international sources, or no funding sources. *Y*-axis for Panel (a) has been truncated to aid visualization for Kakadu, where funding by 'Both' is influenced by small sample size ($n = 4$) and one paper with impact factor of 69.5. Black line indicates the median value, the box indicates the interquartile range, whiskers indicate minimum and maximum excluding outliers, the circles indicate outliers >1.5 × interquartile range and the stars indicate outliers >3 x interquartile range. See Table 3 for test statistics.

4.1 | Parachute science versus internationally collaborative science

The absence of authors from the country in which a study was conducted and, to a lesser extent, scientists from that country not being the lead author in international collaborations, may indicate a risk of research being insufficiently aligned with local needs or insensitive to local socio-ecological context.

Potential parachute science practices, as assessed by papers with only out-of-country authors, were more prevalent in Kruger (18%) than in Nahuel Huapi (4%) and Kakadu (2%). Collectively, these percentages are in line with prior reviews of the conservation science literature, which found that 2%–17% of papers conducted on Global South sites lacked national authorship (Hazlett et al., 2020; Miller et al., 2023). However, patterns in the results—with Nahuel Huapi having similar figures to Kakadu and contrasting with Kruger—did not match expectations based on our classification of the countries and their national parks as belonging to the Global North (Australia) or Global South (Argentina and South Africa). Additionally, Kruger exhibited lower national first author-led publications (62%) than both Nahuel Huapi (94%) and Kakadu (93%). Similar trends in first authorship from national authors to those observed in Kruger have been demonstrated before in broader studies on conservation (62%) and tropical ecological research (38%) (Hazlett et al., 2020; Stocks et al., 2008).

The result for Kruger perhaps echoes concerns raised in the literature about studies conducted in the Global South, while the differences between Kruger and Nahuel Huapi illustrate that the situation may vary between parks and between countries. The results also indicate differences in the role of international researchers in the Global South parks compared with the Global North that make it difficult to draw simple conclusions about parachute science. Papers with both national and international authors were twice as common in Global South parks compared to the Australian park (Table 1). Therefore, although Nahuel Huapi may appear similar to Kakadu from the perspective of lack of potential parachute science in the form of excluding national authors, it is more comparable to Kruger when focusing on papers in which national and international authors collaborated. Both Kruger and Nahuel Huapi also benefited from much greater international funding than Kakadu. This suggests that not only was there greater international interest in both the Global South parks compared to the Global North park but also that much of this international interest led to collaboration with, rather than exclusion of, within-country scientists. While it is uncertain how broadly this trend extends, our findings illustrate the importance of not disregarding the value of international collaboration for national scientists and local managers by assuming that international interest necessarily leads to parachute science. Our results suggest that, under conditions conducive to international collaboration, as seems to be the case in Kruger

TABLE 3 Test statistics for differences between the impact factor and annual citation rate based on funding of studies conducted across the case study parks.

Impact factor					Annual citations				
Kruger National Park									
$H=7.092$; $n=100$; df $=3$; $p=0.069$					$H=11.210$; $n=100$; df $=3$; $p=0.0106$				
	National	International	Both	None		National	International	Both	None
National	—				National	—			
International	0.113	—			International	0.091	—		
Both	1	0.689	—		Both	0.114	1	—	
None	1	0.342	1	—	None	1	0.089	0.092	—
Nahuel Huapi National Park									
$H=14.115$; $n=100$; kdf $=3$; $p=0.003$					$H=11.793$; $n=100$; df $=3$; $p=0.008$				
National	–				National	—			
International	1	—			International	1	—		
Both	0.007	0.202	—		Both	0.124	1	—	
None	1	1	0.002	—	None	0.606	0.141	0.007	—
Kakadu National Park									
$H=5.03$; $n=93$; df $=3$; $p=0.169$					$H=1.633$; $n=93$; df $=3$; $p=0.652$				
National	—				National	—			
International[a]	1	—			International[a]	1	—		
Both[a]	0.208	0.288	—		Both	1	1	—	
None	1	1	0.335	—	None	1	1	1	

Note: The Kruskal–Wallis test statistic (H) and the associated p-value are provided at the top of each matrix, with the Bonferroni adjusted p-values of the Conover–Iman pairwise comparisons appearing within the matrices (dark grey $p<0.05$; light grey $p<0.10$).

[a]Indicates sample sizes of $n\leq 5$.

and Nahuel Huapi, Global South parks can potentially benefit from the knowledge generated by the additional funding and research capacity from heightened international interest.

PAs in developed countries, while possibly at lower risk of non-inclusive research practices by international researchers, might instead suffer from some lack of international interest. In Kakadu, the risk of international parachute science was low, but so was collaboration between national and international authors and access to international funding (Table 1). Whether this pattern holds more widely will need to be tested by evaluating a broader range of case studies. While studies on parachute practices often focus on the lack of local authors in Global South studies (e.g. Mabele et al., 2023; North et al., 2020), fewer contrast this to the potential isolation stemming from a lack of internationally diverse authorship for studies conducted in the Global North. Even iconic PAs in the Global North may potentially be missing out on the benefits obtained through well planned, collaborative, co-funded and co-designed international research.

The risk of parachute science practices needs to be balanced against the potential benefits of enhanced research productivity (i.e. more research getting conducted in a park), increased cross-national collaboration opportunities, amplified funding prospects (and to some extent the possibility of heightened research impact) associated with international authors. These benefits of course do not negate the need to address parachute science practices. For example, it is important to ensure that increased international funding focuses attention on local issues (e.g. Singeo & Ferguson, 2023) rather than research agendas from foreign funding agencies, and that it benefits both foreign and national scientists (e.g. Mabele et al., 2023; Overland et al., 2022). Another risk to be mindful of is developing a dependence on international funding, which may not be sustainable. Nonetheless, our results highlight that if parachute science practices are addressed, then a multitude of benefits could be obtained from the international research interest. Therefore, studies investigating parachute science should consider their results in the context of the potential for collaborative approaches and real-world impact. Neglecting to do so could result in biased narratives that portray disengaged international researchers, failing to acknowledge the manifold benefits these researchers can bring to the parks, as well as the collaborative opportunities for both national and international researchers. If national and international researchers and funders are aware of the potential risks of parachute science and misaligned research agendas, then they can work together to create mutually beneficial opportunities.

4.2 | Research inclusive of conservation management agencies

Relatively few papers included PA agency staff as principal- or co-authors (10%–32%). Considering the often limited in-house science capacity in PAs (Roux et al., 2019), it is not surprising that external

scientists dominate research in parks. Arguably more concerning is that a significant proportion of the externally authored papers examined did not acknowledge the park management agency or its staff (Table 1). Failure to involve or even acknowledge the local managing authority (akin to not engaging local communities) may be indicative of non-inclusive research practices. Our data suggest that this form of parachute science (which we term 'park parachute science'), where external scientists conduct research in parks without engaging the local conservation management agency, seems to be more prevalent than the conventional, more narrow notion of parachute science focused on the nationality of authors. It is arguably a more significant issue than the international versus national distinction when the research relates to conservation science, as involvement of local staff, as opposed to researchers from the country more generally, is likely to make the most difference to the relevance of the research and the application of its results.

The risk of park parachute science is seemingly not affected by the economic status of a country and might be independent from the degree to which a park suffers from conventional parachute science. This point is illustrated by Kruger, which, even when having the largest percentage of solely international papers, also had the highest percentage of papers with PA agency staff as authors. This further highlights that focusing only on international versus national authorship may give an overly simplistic picture of the occurrence of parachute science. We highlight that park parachute science may be led by researchers of any nationality, belonging to the park's home country or a different one.

While not every paper requires co-authorship with park scientists or managers (avoiding 'guest authorship'; Logan et al., 2017), an absence of any acknowledgment for the managing agency or its staff or traditional land owners raises concerns about engagement, integration and respect. The case study parks have procedures in place for agency approval of research projects (Appendix S1), but our analysis suggests that this process is not always effective in closing the gap between research and management. Conservation management agencies are often understaffed, confronted by many pressing issues and facing many unplanned eventualities on a day-to-day basis, which may hinder practitioners' ability to engage and collaborate with scientists, leaving them with limited time for even reading the scientific literature that emerges from relevant research (Walsh et al., 2019). Equally, researchers may not invest sufficient time and energy in engaging with and acknowledging the needs and contributions of the likely end users or in communicating the research findings to the park and translating them into clear recommendations for management.

Having applied research needs of a particular PA explicitly listed can possibly stimulate researchers to design studies in order to fill these knowledge gaps. Whatever the current barriers, we suggest that the more inclusive and collaborative the approach to planning, delivering and communicating research, the more research will align with the needs of park management and the greater the uptake of research findings will be (Fazey et al., 2005; Fernández, 2016). Park management needs often include applied research that improves understanding of the systems being managed, informs management actions (e.g. on appropriate fire- or river-flow regimes), subsequently enables measuring and monitoring the outcomes of the management actions and, finally, closes the learning loops by reflecting on the efficacy of the management actions and suggesting alternatives if needed (i.e. adaptive management; e.g. Roux & Foxcroft, 2011). Within that broad framework of common themes, specific questions of greatest importance will vary from place to place and over time. Identifying and removing barriers between scientists and practitioners can help to target research towards the highest priorities, benefit both parties and lead to positive conservation outcomes (Vargas et al., 2022).

4.3 | Absorptive capacity as the mechanism to unlock external collaboration

Collaborative research requires engagement from both sides. A conservation agency's ability to engage with external knowledge, termed 'absorptive capacity', is influenced by recognizing the value of external information and then assimilating and applying it (Cohen & Levinthal, 1990). Key determinants of absorptive capacity include prior related knowledge, capacity for research and development, associated knowledge networks and the presence of gatekeepers or boundary workers (Murray et al., 2011). Even a small but continuous presence of internal research and development capacity, or knowledge and skills relevant to bridging the knowledge-action divide, can significantly increase the absorptive capacity of an organization (Schmidt, 2005).

Embedded scientists, and management staff with scientific skills and interest, can enhance the absorptive capacity of PAs by facilitating collaboration with external scientists and associated knowledge systems (Roux et al., 2019). Their knowledge and experience of park management, relevant research topics and an ability to bridge internal and external knowledge systems positions them strategically to play this role. A few individuals can arguably make a disproportionate difference—for example, <2% of Kruger staff are embedded scientists, but they contribute to Kruger being one of Africa's most researched and published PAs (Smit et al., 2017). The creation of formal place-based hubs, such as Zimbabwe's Hwange Long-Term Socio-Ecological Research site, can also facilitate knowledge exchange between academics, students and management agency staff.

4.4 | Benefits of international collaboration and funding

International research partnerships with national researchers and park staff offer potential for co-learning, increase the legitimacy of conservation solutions, reduce the risk of conflict with local communities and provide access to relevant expertise (Singeo & Ferguson, 2023). In addition, our study reveals the potential for increasing research productivity (i.e. more papers per park than in the absence of international

researchers), funding and to some extent the impact and visibility of the research (as measured by journal impact factor and citation rate) through international collaboration (Figures 1 and 2; Tables 2 and 3). Increased research activity and visibility can snowball, creating further opportunities for networking and funding.

4.5 | Caveats and study limitations

Using primary affiliations may overlook national authors studying at or being funded by international institutions (Rayadin & Buřivalová, 2022) or expats based at international institutions who are conducting research in their home country (Mwampamba et al., 2022). Likewise, it does not capture the length of time researchers may have been associated with a country or their depth of knowledge of a park. We also acknowledge that co-publication does not capture all dimensions of engagement and collaboration, such as capacity building and translating research into policy interventions (Dangles et al., 2022).

Recognizing the limitations of journal impact factors (e.g. Lariviere & Sugimoto, 2019), we acknowledge that place-specific and applied research in regional journals may be more impactful for local management issues than broadly relevant papers in prestigious international journals that often prioritize conceptual studies or focus on advancing theory rather than directly informing practice (Choi et al., 2024). The trade-off between 'locally useful' and 'globally (and career) relevant' is evident in areas requiring basic knowledge or place-based, transdisciplinary research (Mwampamba et al., 2022; Sellberg et al., 2021). Journal impact factor or the citation rate of individual papers may be accessible metrics for gauging scientific reach and impact, but not be the best measure of the true value and uptake of research by park management. There are other relevant indicators for measuring the influence of research (Lavery et al., 2021); however, these can require the detailed investigation of individual projects. Future studies could possibly explore whether scientific studies get cited in management documents. For example, the Kruger Management Plan (2018–2028) cites 129 references, many of which are from scientific publications. We also acknowledge that the impact of scientific research on park management may not be directly linked to specific influential studies or papers. Instead, based on our experience, it is typically a broader body of scientific evidence emerging from many studies that interacts in complex and indirect ways with evolving societal values and policy changes, ultimately driving trends and shifts in conservation management. Future studies could take a qualitative approach to explore with PA managers whether, and how, research conducted in their parks has assisted them. This would help to better understand when such science is useful to practitioners, how research results are most effectively communicated to them (likely not through academic papers) and whether the nationality of the authors and their direct involvement in the research may play a role.

Although the extraction of funding information cited within papers is often employed to analyse funding patterns in research (Cronin, 2001), we recognize that some funding sources may be omitted for political or cultural reasons or pure forgetfulness (Mejia & Kajikawa, 2018). Also, it was beyond the scope of this study to ascertain how the funding was partitioned between the national and international researchers, and the degree to which the national scientists benefited from funding. Furthermore, we acknowledge that it is not possible to evaluate the depth and meaningfulness of engagement with the park based on brief notes in the acknowledgements section. The data we present are, therefore, more illustrative of the need to encourage and increase meaningful engagement between park staff and external scientists.

Because we employed a case study method involving iconic PAs rather than a more comprehensive survey across many PAs, it may not be possible to extrapolate our results beyond the selected parks. However, the results do provide useful (albeit not exhaustive) archetypes offering valuable insights and practical lessons (see next section) often overlooked in studies of conventional parachute science aggregated across a journal, discipline, country or continent. Future studies can explore similar patterns in lesser known PAs and in a wider range of lower- and lower-middle-income countries where different dynamics may be involved. Given the well-established geographic bias in published research (Di Marco et al., 2017), a sample reflecting this bias may also yield valuable insights into the factors driving 'park parachuting' science.

4.6 | Initiatives of managing agencies to stimulate collaborative research

Drawing on the insights of PA managers and scientists from the three case studies, we highlight key ongoing initiatives in each park to foster collaborative research and increase alignment with park knowledge needs.

4.6.1 | Kruger National Park

Kruger has hosted the annual Savanna Science Networking Meeting for over two decades, bringing together around 200 conservation managers and scientists to share savanna-related research findings (https://www.sanparks.org/scientific-services/events). This international conference provides a networking platform across disciplines, nationalities and the science–practice interface. These meetings act as a catalyst for collaborative projects within Kruger (and beyond) that benefit individuals, the park, South Africa and the global savanna research community.

The project registration process has become a vital mechanism for joint learning (Biggs, 2004). During the project registration process, a local in-house scientist (with matched expertise in the specific field, where possible) is assigned as coordinator for each proposal who circulates it to in-house scientists and managers for inputs, collating inputs and acting as liaison between the park and the researcher. As part of the process, the coordinator provides local context, insights on how to increase local relevance of the research

and makes the external researcher aware of relevant papers, data and other scientists studying similar issues in the park. These interactions often lead to collaborative research, benefitting both the park and external researchers. The process is free of charge and emphasizes an intellectual rather than a financial exchange.

4.6.2 | Nahuel Huapi National Park

Nahuel Huapi employs various mechanisms to foster collaboration with external researchers, particularly from within Argentina. For example, the park has established long-term institutional arrangements with the Universidad Nacional del Comahue. As part of this collaboration, the park provides and co-manages infrastructure, such as a biological station, in a unique temperate rainforest, and offers office space for national researchers, serving as their workplace. Additionally, the park funds scholarships for local college students, enhancing its appeal as a research destination. These initiatives create a conducive environment for rich exchanges and cooperation with external partners, promoting knowledge production and management-relevant research to benefit conservation. They offer opportunities for a more 'situated' approach to research.

4.6.3 | Kakadu National Park

Kakadu prioritizes research to address the most important knowledge gaps impeding management. Research and monitoring investment in the park is coordinated by a group of ecologists and natural resource managers on staff, supported by two scientific committees - the Kakadu Research and Management Advisory Committee and the Bininj/Mungguy Research Advisory Committee - and by a central science group in the wider Parks Australia agency Parks Australia works collaboratively with research partners and engages closely in programmes funding applied science, such as the Australian Government's National Environmental Science Program (NESP), to co-design and co-deliver research. Projects funded through NESP have benefited from a knowledge broker to facilitate addressing the perspectives of Bininj/Mungguy traditional owners and the translation of research into recommendations for management.

4.6.4 | Actions to stimulate collaborative research

Building on the park-specific arrangements outlined above, we propose the following actions to promote collaborative research:

- Clearly outline the process for external scientists to engage with the national park agency when registering new research projects. The focus should be on creating an engaging and efficient process that emphasizes co-learning and fosters a research-enabling environment, while promoting alignment with agency priorities and ensuring compliance with permit conditions.
- Maintain an up-to-date list of research needs, developed by park managers with in-house scientists and advisory groups, that are visible to external research collaborators. This can also be used to attract research to lesser studied and lesser known parks if well-designed and prominently displayed.
- Build long-term partnerships and networks to co-design projects on priority topics from the planning stage, rather than learning about them only at permit application stage.
- During screening of research permit applications, inform proposers of opportunities and expectations for engagement with the park agency and other scientists working on similar issues.
- Request external scientists to submit original data, research outputs and feedback on management implications upon project completion.
- Ensure that embedded conservation agency scientists have time for collaborative research and co-supervising postgraduate students, enhancing research relevance for PAs and fostering relationships with academic institutions, staff and students.
- Encourage conservation agency staff to attend and participate in relevant conferences to build collaborative relationships and showcase the value of applied science in conservation management.
- Broaden the evaluation of scientists in universities to include more than just academic outputs (e.g. citation rates and journal impact factors). It is important to recognize and reward scientists who invest time in engaging with the end users of their research, such as PA managers. Co-creating and disseminating research requires considerable time and effort and should be formally recognized and rewarded in the career progression of scientists.

5 | CONCLUSIONS

There are growing concerns over the practice of parachute science which can potentially lead to misalignment with local needs, insensitivity to the local context and a lack of investment in and use of local expertise. While our case studies identified instances of potential parachute science, where international authors fail to include national collaborators and where external scientists overlook local park agency staff, our findings also show that international research interest can foster collaboration. Such efforts can benefit in-house, national and international researchers, as well as the parks themselves. Protected areas that do not engage in collaborative research miss out on these benefits even if they avoid parachute science. Research by both national and international scientists should be responsive and sensitive to local needs and issues and be conducted in a collaborative manner with the park authorities and staff. Achieving such collaboration requires active and deliberate effort, with a shared responsibility of visiting and local scientists and a need for protected area agencies to maintain the capability for meaningful research engagement.

AUTHOR CONTRIBUTIONS

Izak P. J. Smit conceived the ideas and designed methods, with inputs from Roberto J. Fernández, M. Fernanda Menvielle, Dirk J. Roux,

Nikisha Singh, Samantha Mabuza, B. Mbali Mthombeni, Herve Fritz, Edson Gandiwa, Llewellyn C. Foxcroft and Carly N. Cook; Izak P. J. Smit, Roberto J. Fernández, M. Fernanda Menvielle, Nikisha Singh, Samantha Mabuza, B. Mbali Mthombeni, Carly N. Cook and Nicholas A. Macgregor collected the data; Izak P. J. Smit analysed the data; Izak P. J. Smit, together with Carly N. Cook, led the writing of the manuscript. All authors contributed to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

Izak Smit is an Associate Editor of *Journal of Applied Ecology*, but took no part in the peer review and decision-making processes for this paper.

DATA AVAILABILITY STATEMENT

Data available from the Dryad Digital Repository https://doi.org/10.5061/dryad.73n5tb366 (Smit et al., 2024).

STATEMENT OF INCLUSION

The geographical distribution of the authorship team represents the three countries from which case studies were selected (South Africa, Argentina and Australia), plus another country due to an author with an interest in the topic (Zimbabwe). In addition, it includes academics, protected area managers and conservation agency scientists. Authors were engaged early on with the research and study design to ensure that the diverse sets of perspectives they represent was considered from the onset and all were included in the final write-up.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. Study site descriptions.

Appendix S2. Summary of searching and sampling framework.

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