

The Scientific and Sociocultural Value of Citizen Science

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*. . . mis venas no terminan en mí
sino en la sangre unánime
de los que luchan por la vida*

*. . . my veins don't end in me
but in the unanimous blood
of those who struggle for life*

Roque Dalton

'Como tú'

Transl. by Jack Hirschman

Declaration of Authorship

I declare that the concepts in this thesis are entirely my own, and the contents of these chapters, except where explicitly stated otherwise through acknowledgement, represent solely my own work. This thesis has not been submitted elsewhere, in part or in whole, towards the fulfilment of any other degree.

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For you, for today, and for what you will build with these words.

FOUNDATIONS



Almost everything important that happens is a process, not an event, and almost all of those processes involve the work and collaboration of thousands or millions or billions of people.

John Green

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ABSTRACT

At its best, conservation science serves as an interface between multiple disciplines, bringing together innovation and insight from the humanities, arts, business and economics, health, natural and social sciences to address the most pressing challenges facing the planet and its biodiversity. Conservation is also unique in its ability to transcend the academic. Subdisciplines such as biological citizen science involve non-academic individuals in data collection and as co-creators in research design and implementation. There is wide theoretical appeal to these initiatives, as they may simultaneously generate enough data for fine-scale biological monitoring and, through community engagement, promote the democratic generation and dissemination of knowledge. However, despite their potential within both the scientific and sociocultural realms, the regional-scale impacts of citizen science initiatives in continental Africa remain poorly understood. Studying local citizen science initiatives affords opportunities to gain an understanding of their impact; within the African context, citizen science participants contribute to African Bird Atlas Projects in fifteen countries by compiling comprehensive avian species checklists at a fine geographic scale. Two projects are of particular interest for analysis: The Second Southern African Bird Atlas Project (SABAP2), and the Nigerian Bird Atlas Project (NiBAP). SABAP2 occupies a unique position as a long-term African citizen science project with ample data for statistical analyses. NiBAP employs an innovative grassroots approach to atlasing and hosts an enthusiastic and growing community of citizen science participants. In addition to impressive datasets, 'atlasers' in South Africa and Nigeria are a wealth of information regarding the personal- and community-level values surrounding participation and motivation. Furthermore, variations in project structure and cultural contexts between SABAP2 and NiBAP allow for some comparison of the values of participants between subprojects and contribute towards an understanding of the broader values of African Bird Atlas Project participants. In light of this potential, this thesis aims to examine the scientific and sociocultural contributions of SABAP2 and NiBAP to the work of conservation—namely achieving fine-scale species monitoring and advancing the democratic generation and sharing of scientific knowledge—within continental Africa. I examine the quality of data collected by a community of SABAP2 atlasers in Hessequa, South Africa, and assess their value in monitoring species population trends. I ask 1. Does systematic atlasing improve the temporal quality of atlas data for monitoring? and 2. Can these data detect trends in species populations and inform local response? Then, I explore values to nature expressed by atlasers and non-citizen science participants in both Hessequa, South Africa, and Jos, Nigeria. I ask the following two questions: 1. Does the type and frequency of values (instrumental, intrinsic, and relational) differ between participants and non-participants, and between cultural contexts?, and 2. what relational values (if any) are linked to participant motivation? Results demonstrate the ability of SABAP2 data to support biodiversity monitoring at a local scale, and show the potential for democratising research by including participants in data collection, analysis and application. The study of values and motivations emphasises the particular importance of relational values in connection with participant motivations and human-nature relationships broadly. Overall, the findings of this research demonstrate the ability of African Bird Atlas Projects and similar initiatives to meet the challenges of contemporary conservation, and lay a foundation for future research into the practical application of co-created monitoring schemes and incorporating values into the design of both citizen science projects and conservation interventions.

CHAPTER 1

An introduction



And at the end of the day, the reality is that whether we change or whether we stay the same/ these questions will remain./

Who are we to be with one another?/ and/ How are we to be with one another?

Pádraig Ó Tuama

'[the]north[ern][of]ireland'

1. The life and history of the ecosystem concept

In 1935, plant ecologist Sir Arthur Tansley coined the term *ecosystem* to describe the relationships he observed between living organisms and their physical environment (Tansley 1935; Trudgill 2007). Within a decade, Raymond Lindeman's research on aquatic systems had re-shaped the term into one which defined the flow of energy between biotic and abiotic system components not only as relationships, but also as a complex inter-reliance (Lindeman 1942). Understanding of the ecosystem concept continued to evolve; throughout the 1970s, its diverse adaptation by both ecologists and non-ecologists led to a nuanced incorporation of humans as components of ecosystems, and the genesis of terms such as *ecosystem integrity* (Bocking 1994). Crucially, as noted by environmental historian Stephen Bocking, these new applications highlighted the importance of and limitations imposed by social context when formulating terminology:

Scientific concepts rarely reflect simply an objective understanding of empirical reality. As the history of the ecosystem concept suggests, their evolution reflects not only our changing understanding of nature, but our evolving sense of the role of science, and of our place in the world. In describing nature, we describe ourselves. By understanding this interdependence of visions of nature, science, and society, we can better understand how science might contribute to fostering respect and protection of the environment (Bocking 1994).

Bocking's statement contains an important insight: That terminology is an echo of reality, and, in many ways, science is an iterative practice of naming what is already true. Such was the case for the ecosystem concept. As it grew to encompass the interconnectedness of everything, living and non-living, within the universe, ecologists came to realise that humans are part of nature, and inherent within the study of the natural world is the study of humans themselves. The rebirth of the ecosystem concept marked the start of a shift in the natural sciences, away from a study of isolated parts and towards an understanding of the whole. From this movement sprang interdisciplinary collaborations between the natural and social sciences, and yet another iteration of the ecosystem concept: The social-ecological system.

The social-ecological system is an attempt to encompass the unfolding relationships and processes linking humans and non-humans within an ecosystem (Ostrom 2007; Moffatt & Kohler 2008; West et al. 2020). As understanding of the intricate connectedness and interdependence of ecosystem components deepens, science is repeatedly confronted with the reality that nothing exists in isolation, and 'nothing' includes *Homo sapiens* (Pimm 2021).

In rural and Indigenous communities, people rely on the land and each other for provision, safety, and social connection (McCormick 1997; Pathman & Ricketts 2009; Remorini 2015; Whyte et al. 2016). Yet this direct connection between people and land is no longer the norm; the majority of the human population now inhabits urban contexts (Kundu et al. 2020; Moreno-Monroy et al. 2021). Urban landscapes are massively reliant on human-driven systems: Large-scale agriculture, transportation, electricity, water sanitation. And these systems, in turn, depend upon social, economic, and environmental provision from rural populations, who remain geographically isolated but are linked to urban clusters through roadways (Tandoh-Offin 2010; Linard et al.

2012; Lichter & Ziliak 2017; Gebre & Gebremedhin 2019). Human interdependence is a natural consequence of complex anthropocentric structures—and this should not come as a surprise. Natural systems are deeply interconnected, and, as humans are part of nature, human existences are also inextricably interwoven. Realising the interdependence of human and non-human nature as well as the *intra*-dependence of humankind reveals the precarious positions of both: In ecosystems characterised by weak or absent human-nature relationships and fractious human-human relationships, biodiversity balances on the edge of knife. The fragility of collective existence points to an urgent need to preserve not only connections between humans and the rest of the natural world or even the natural world and itself, but also between humans and other humans. The task of modern science becomes one of internal transformation (Rands et al. 2010), re-imagining existing structures and ways of collecting and understanding data to include relationship, culture, language, and thought. Thus, this thesis rises from a social-ecological framework, from a pressing need to see, consider, and conserve the entirety of the complex and unfolding relationships connecting all systems—living and non-living, human and non-human—on earth.

2. Biodiversity loss through a social-ecological lens: Re-imagining preservation as conservation

The social-ecological system concept arrives at a moment of crisis in conservation. Anthropogenic climate change, overexploitation and land transformation continue to accelerate the widespread loss of species, habitats and biodiversity (Western 1992; Horváth et al. 2019; Watson et al. 2019; Chase et al. 2020). In the past century (and particularly in the Global South), much of the work of conservation has centred on mitigating losses through a focus on non-human species and the establishment of areas protected from human intervention (Siurua 2006; Brockington 2015; Holmes & Cavanagh 2016; Rai et al. 2021). The practice stems from a colonial preservationist ideology which posits that humans must be kept separate from the rest of nature to ensure its protection, and considers true nature as ‘wilderness,’ or land untouched by humans (Sarkar 1999; Adams & Hutton 2007; Brockington 2015; Gumbo 2019; Banerjee & Dunaway 2023). Multiple protected areas internationally have adopted this preservationist management approach, creating and enacting strict protection policies for species and landscapes—and yet, despite some mixed successes (West & Brockington 2006; Dudley & Stolton 2010), biodiversity loss persists, and the human-exclusionary practices have created additional problems. As a by-product of exclusion, conflicts concerning land access and use arise between conservation scientists and the non-scientists who inhabit and are also invested in local ecosystems (Sarkar 1999). Among other complications, the consequences of conflict manifest as ineffective policy (Cavanagh & Benjaminsen 2017), social inequalities (Sanderson & Redford 2003; Garland 2008; Peterson 2015), and complex ethical dilemmas (Chatty & Colchester 2002; Dowie 2005; West & Brockington 2006; Luoma 2022). The continued and rapid loss of biodiversity means that conservation needs to shift its focus from preservation to monitoring in all habitats, whether protected, semi-natural, or urban, to understand and proactively respond to changes in ecosystems and species populations (e.g. Gregory 2006; Cooper et al. 2007; Theobald et al. 2015; Ferreira et al. 2021). Crucially, such monitoring cannot be achieved in isolation from local people (Garritt 2006). Recognising the need for a new paradigm, interdisciplinary teams of academics and conservation practitioners have begun to

urge that preservationist practices be re-considered in favour of human-inclusive, integrative and participatory approaches, partnering with communities and diverse non-scientific knowledge holders to craft meaningful interventions (Brown 2003; Büscher & Wolmer 2007; De Santo et al. 2011; Domínguez & Luoma 2020). Thus, emerging from a preservationist era and into the language of social-ecological systems, contemporary conservation can be characterised by three challenges: 1. Biodiversity monitoring (scientists do not have the right data, or enough of it, to monitor ecosystems); 2. Democratic participation (not enough of the people affected by biodiversity loss are informed or involved regarding ecosystem conservation); and 3. Inclusive interventions (current interventions do not adequately consider or understand the humans inhabiting these systems).

The problem of data scarcity is not novel. Lack of funding and human resources and limited land accessibility due to remoteness or privacy are well known limitations on data collection efforts (Garnett et al. 2003; Brooks et al. 2006; Morais et al. 2013; Lee-Yaw et al. 2021). These result in significant shortfalls in data which stymie effective biodiversity monitoring (Hortal et al. 2015). Although there are not enough professional scientists to support global monitoring, the possibility of entrusting data collection to non-professionals carries the risk of compromising a standardised protocol and data integrity (e.g. Flanagan & Metzger 2008; Lagoze 2014; Riesch & Potter 2014). However, this (albeit legitimate) concern recreates the broader problems of a preservationist perspective. Reluctance to include non-scientists in data collection and decision-making can compound existing cycles of inequality between scientific professionals and the broader public; the second challenge of contemporary conservation. When a few professionals attempt to manage complex ecosystems without incorporating the conservation knowledge and values of local people and without clearly communicating their own knowledge, they risk implementing interventions that are locally ineffective. Furthermore, they may lose support from the people who will ultimately determine the long-term success or failure of any intervention (Garritt 2006; West & Brockington 2006; Sandbrook et al. 2019; Ogar et al. 2020). This leads to the third challenge: Crafting interventions that adequately consider and understand humans as ecosystem inhabitants. A preservationist approach broadly describes human influence as harmful, and thus dismisses possibilities for humans as co-creators, co-habitants, or stewards of the systems they inhabit. Yet growing understandings of ecosystems tell a different story: That humans are both environmental actors *and* environment; nature acting on behalf of itself (Barragan-Jason et al. 2023). Thus, a social-ecological (or, alternatively, biocultural) conservation approach requires that people are seen as *vital*—life-giving—components of their ecosystems, with the capacity to design and uphold meaningful conservation interventions (Elands et al. 2019).

The three challenges to contemporary conservation are problems of logistics and power (e.g. Dempsey 2022; Shackleton et al. 2023): How can conservation scientists obtain the high-quality species presence data needed to monitor local and global population trends, and how can they include, inform, and learn with the people who are part of the systems they seek to protect? Solutions may lie in the field of citizen science.

3. Citizen science: a transdisciplinary frontier

Citizen science first emerged as a formal concept in the late 1900s; however, its origins reach further into the past (Strasser et al. 2019). Prior to the mid-1800s when the term ‘scientist’ debuted as a profession, the majority

of scientific ecological research was conducted by amateur naturalists and independent hobbyists, and was often directed by religious and government institutions (Porter 1978; Sparks & Carey 1995; Brenna 2011; Vetter 2011; Miller-Rushing et al. 2012, 2020). Agricultural communities and local governments also collected environmental data, monitoring phenological changes between subsequent years in the timing of phenomena such as tree blossoming (Aono 2015), and keeping detailed records of dates of sowing, harvest, and pest outbreaks stretching back hundreds and, in some cases, thousands of years (Chuine et al. 2004; Garnier et al. 2011; Tian et al. 2011). However, following the professionalisation of science as an academic pursuit, a conceptual divide arose between the layperson and the scientist. People who had previously served as the primary generators of scientific knowledge were slowly replaced by ‘learned’ academics (Beer & Lewis 1963; Drouin & Bensaude-Vincent 1996; Miller-Rushing et al. 2012; Mahr & Dickel 2019). As science developed a professional body of researchers and literature, it began to overshadow the efforts and datasets collected by amateurs; indeed, as noted by Drouin and Bensaude-Vincent (1996, p. 418), the term ‘amateur’ took on a negative connotation: “*The old positive meaning of ‘connoisseur’ has gradually been overthrown by the pejorative sense of ‘dilettante’ emphasising a lack of seriousness and reliability.*” Yet despite the scientific culture shift towards exclusivity, amateur naturalists continued to observe and record aspects of the non-human natural world, occasionally working alongside professionals (Alberti 2001; Silvertown 2009). From the mid-twentieth century onwards, the formalised citizen science concept and the advent of personal technology became crucial players in reconnecting scientific and amateur naturalist communities. Applying an ancient technique through a novel power dynamic, professional scientists began to harness the enthusiasm and skill of amateurs by crowdsourcing, motivating groups of volunteers to collect data en masse (Cohn 2008; Lowman et al. 2009; Silvertown 2009; Devictor et al. 2010; Yaukey 2010). This ‘new’ citizen science benefited professional scientists in at least two ways: Firstly, volunteers were able to collect data at scales unattainable by professionals alone, and secondly, citizen science projects could generate detailed data at very local scales—data that were necessary to the wider goals of ecology and conservation, but were often considered too narrow in focus to be of interest for funding or publication (Cooper et al. 2007; Couvet et al. 2008; Miller-Rushing et al. 2012; Strasser & Haklay 2018; Callaghan et al. 2021b). A third benefit also garnered attention, illuminated through studies of Indigenous and local knowledges. Many non-scientists held deep personal and historical knowledge and connections with their local environments, and these insights could enrich scientific thought and conservation practice (Mackinson & Nottestad 1998; Garritt 2006; Mazzocchi 2006; Sobrevila 2008; Bonta 2012).

Although the benefits of citizen science were appealing, achieving them proved challenging. Problems of exclusivity, exploitation, and undemocratic practice quickly became evident as citizen science popularised, along with substantial critique regarding the quality of data collected by citizen science participants (see Chapter 2). These challenges led to critical inquiry into various aspects of establishing and maintaining citizen science initiatives, ranging from the level of participant involvement (e.g. Bonney et al. 2009a,b; Land-Zandstra et al. 2021) and participant diversity (Pandya 2012; Davis et al. 2020; Pateman et al. 2021; Pateman & West 2023) to protocol structure (Conrad & Daoust 2008; Wiggins & Crowston 2011; Freitag et al. 2016; Callaghan et al. 2021a) and data quality and communication (Wiggins et al. 2011; Bonter & Cooper 2012; Kosmala et al. 2016; Rufenacht et al. 2021). While still ‘young’ as a tool for study, the rapid surge of interest and research into the inner workings of citizen science generated a massive body of literature and began to build a terminology and

understanding of best-practice recommendations for its applications. As a result, within 150 years, citizen science moved from asking “can non-scientists contribute?” to “how do non-scientists contribute?” By the 2010s, professional scientists and citizen science participants were in many cases working together on *participatory* and *co-created* projects, jointly designed by scientists and participants and intended to include the diverse people and perspectives inhabiting the systems under study (cf. Chapter 2). Today, scientific and public interest in citizen science has supported the establishment of projects on terrestrial, freshwater and marine ecosystems, generating biodiversity data from some of the most data-poor regions of the world and engaging diverse communities in scientific research (Theobald et al. 2015; Chandler et al. 2017; Kelly et al. 2020). Contemporary projects are continually evolving, incorporating perspectives from the social sciences, statistics, environmental psychology, economics, philosophy, and social justice to improve the quality and impact of their data and pursue an increasingly inclusive conservation.

4. Atlas projects as citizen science initiatives in Africa

Among the varied citizen science projects contributing to biodiversity conservation, many are taxon-specific, focusing on a particular class, order, family, genus, or species (Theobald et al. 2015). Birds are one of the most commonly studied classes; they are (generally) conspicuous, charismatic, identifiable with practice, and are present in every habitat type on the planet (Gregory 2006; Lloyd et al. 2020; Feldman et al. 2021). International citizen science databases such as eBird (Sullivan et al. 2009) amass millions of records every month but employ a loosely structured data collection protocol and a contributory framework (participants are involved only in the collection of data). Whilst the volume of records mitigates many of the subsequent potential problems in data quality, quality is still compromised by spatial, temporal, and observer biases (e.g. Zhang 2020; Johnston et al. 2021; Robinson et al. 2022; Scher & Clark 2023); these effects become increasingly troublesome at smaller scales, where fewer observers and a lower volume of records can increase the impact of any problematic records. Hence, at the local scale, many citizen science initiatives are designed with a more heavily structured protocol (e.g. Praveen et al. 2022).

A structured protocol affords multiple benefits from a statistical perspective, minimising bias from the outset and improving the overall quality of data for analysis (Chapter 2, 3). Bird atlas projects are a popular choice in this regard and have been implemented in nearly 100 countries (Donald & Fuller 1998; Gibbons et al. 2007; Dunn & Weston 2008; Pototsky & Cresswell 2023). For an atlas project, the region of interest is divided into squares of uniform size. Atlases employ a data collection protocol which requires participants to compile comprehensive lists of the species they identify within each square (the specific benefits of a structured protocol and grid-based atlas are explored in Chapters 3 and 4). Many atlases run for a pre-determined length of time and aim to create a ‘snapshot’ of biodiversity within a specific time period. Some, however, are open-ended, with a goal of continuous biodiversity monitoring. This is the approach adopted by the African Bird Atlas Project (Brooks et al. 2022), a network of national and regional bird atlases across Africa with data housed at the Fitzpatrick Institute of African Ornithology at the University of Cape Town, South Africa.

The Second Southern African Bird Atlas Project (SABAP2; <https://sabap2.birdmap.africa/>; Underhill et al. 2017) was the first African Bird Atlas Project to be established, and its data collection protocol, BirdMap,

served as the model for all subsequent projects (Brooks et al. 2022; Chapter 3, 4). SABAP2 collects records from South Africa, eSwatini, Lesotho, Mozambique, Zimbabwe, Botswana, Namibia, Malawi, and Zambia, and since its launch in 2007, the African Bird Atlas Project network has expanded to include projects in Nigeria and Kenya and informal projects in Sierra Leone, Liberia, Ghana, and Uganda (Brooks et al. 2022; birdmap.africa). As a prominent African citizen science initiative, African Bird Atlas Project practitioners should consider its impact in addressing the three challenges to contemporary conservation: How do atlas projects contribute towards biodiversity monitoring, democratic participation, and inclusive interventions?

Data for biodiversity: Using reporting rates to monitor populations

Perhaps the greatest strength of any atlas project is its potential to support the monitoring of species populations and distributions (Underhill & Gibbons 2002; Robertson et al. 2010; Lee et al. 2021; Squires et al. 2021; Lee & Hammer 2022). Atlases afford opportunities to collect data at fine spatiotemporal resolution and unprecedented scale without, in theory, compromising data quality. This is true of the oldest and largest African Bird Atlas Project, SABAP2.

Detecting trends in species populations requires a tool sensitive enough to detect subtle shifts, and blunt enough to characterise large changes. For SABAP2 data, reporting rates offer a suitable starting point. The reporting rate for a species is defined as the proportion of checklists on which it has been recorded; a concept that dates back to Linsdale (1928) who intuited that reporting rate would provide an index of abundance. Following Linsdale's work, the next important quantitative development was made by Temple & Temple (1984, 1986), who showed that count data and reporting rates were closely correlated using Spearman's rank correlation coefficient. The use of this measure of correlation demonstrated an understanding of the reality that reporting rates are monotonically related to abundance, and the relationship is not linear (Underhill et al. 1992). This concept was further advanced by Griffioen (2001), who recognised that mathematical ecology developed by Nachman (1981) could be applied to the relationship between abundance, denoted by N , and reporting rate R . Using data originating in the Australian Bird Count project (Ambrose 1991), he demonstrated that the relationship between the $\log(N)$ and $\log(-\log(1-R))$ was linear. The theoretical implications of Griffioen's (2001) results are explored in Underhill (submitted).

Although straightforward, the use of reporting rates to measure population trends remains a challenge. Potential biases inherent within the data invariably impact the validity of results. SABAP2 was preceded by another atlas project, SABAP1, with a more relaxed protocol than SABAP2 and coarser spatial and temporal resolutions (Underhill et al. 1992; Harrison et al. 1997). While reporting rates from SABAP1 did generally reflect estimates of abundance, inconsistencies in sampling effort were an accompanying caveat to utilising the data to estimate abundance (Robertson et al. 1995). The problem of observer effort remains a concern in any atlas data analysis (e.g. Szabo et al. 2010, 2012; Huntley et al. 2012), along with seasonal and behavioural variations in the conspicuousness of a species and potential misidentifications by observers (Harrison & Underhill 1997).

Robertson et al. (2010) list seven qualities which should ideally characterise a data-strong atlas project: A spatial scale appropriate to the study taxon; the highest possible spatial and temporal resolution; the highest possible

taxonomic resolution (e.g. species level identifications rather than family level); the highest possible demographic resolution (e.g. inclusive of life stage and age information); a standardised protocol with a reliable indication of sampling effort; a well-described sampling protocol; and the greatest possible number of unique sampling units (e.g. pentads). Several of these components were already included in SABAP1, and either carried over or were introduced into SABAP2. The spatial resolution of the project was increased from quarter-degree units of 15×15 minutes latitude by longitude to the pentad (5×5 minutes latitude by longitude), and the temporal resolution increased from a monthly to a five-day interval. By introducing a minimum 2-hour atlasing protocol, SABAP2 reduced the uncertainty surrounding sampling effort. To minimise the chances of missing inconspicuous or seasonally gregarious species, a dimension of thoroughness was added to the sampling protocol by requiring ‘atlasers’ to visit as many habitat types as possible within each pentad. Finally, to address the problem of misidentification, new SABAP2 checklists were vetted automatically against existing records for the region, and panels of regional identification experts were tasked with reviewing incoming checklists and querying unusual records (Brooks et al. 2022). While the precautions built into SABAP2 certainly do not eliminate bias, they are designed to minimise its presence in checklists. Thus, SABAP2 reporting rates can be considered a reasonably robust metric for monitoring avian population trends (e.g. Lee et al. 2017) and are the subject of Chapter 3.

Democratic participation: SABAP2 and Hessequa atlasers

Data from SABAP2 are potentially powerful tools for biodiversity monitoring, but monitoring is ineffective if the people directly affecting species are not included and informed regarding their conservation. Citizen science atlases are generally considered capable of engaging diverse individuals in scientific research (Greenwood 2007; Harrison et al. 2008) and are often promoted as tools for building community awareness surrounding conservation issues (Taufiqurrahman et al. 2016; Harrison 2020; Phillips et al. 2021). For the African Bird Atlas Project, beneath the umbrella of a unified structured protocol, there is still scope to include citizen science participants in multiple aspects of project design, formulating locally relevant conservation questions and processing and disseminating results together. The unified spatial unit and protocol across continental Africa enables data comparability, whilst also allowing each country to tackle the challenges of fieldwork, data analysis, and communication of results in unique and context-specific ways. For instance, Kenya Bird Map (<https://kenya.birdmap.africa/>) is run in partnership by a local museum, research institution and conservation organisation (Wachira et al. 2015; Kung’u & Jackson 2017), whilst in Nigeria, atlasers with the Nigerian Bird Atlas Project (NiBAP; <https://nigeria.birdmap.africa/>) are organised around a network of local bird clubs and meet regularly to collect data together as teams (Ringim et al. 2022). Allowing countries to take ownership of project logistics eschews the pitfall of imposing what ‘works’ in one context onto every context, whilst maintaining the integrity of data through a structured protocol. Yet despite the clear potential, no studies have examined atlas participation as a component of democracy—or the impacts of local innovation on data quality. Within South Africa, there is potential to explore both subjects.

Hessequa, a region in the Western Cape where atlasers have initiated a local bird monitoring project, provides a unique opportunity to study the generation, dissemination, and quality of data in an African Bird Atlas Project. Fieldwork efforts in Hessequa were erratic from the launch of SABAP2 in 2007 until 2014, when local atlasers

began pursuing seasonal monitoring targets across two-year cycles (van Rooyen & Underhill 2020; Figure 1). The monitoring strategy began with a chessboard pattern for the region, dividing the atlas year into four austral seasons: Summer (December—February), Autumn (March—May), Winter (June—August) and Spring (September—November). Over a two-year period, the ‘black’ pentads of the chessboard received fieldwork in summer and winter during the first year and autumn and spring during the second year, and vice versa for the ‘white’ pentads. In this way, every pentad was scheduled to produce a checklist in every season by the end of a two-year atlas cycle, with structure to the patterning of the seasonality. Efforts were coordinated by Johan van Rooyen, leader of the local U3A Stilbaai Bird Group. Van Rooyen, a keen atlaser, introduced the idea of an atlas project by hosting a trial atlas day, dividing participants into six groups and sending each out with at least one experienced birder to compile a bird checklist in different parts of the same pentad (van Rooyen, personal communication). The four groups together compiled a list of more than 100 species, and those who enjoyed the experience committed to atlasing a certain number of pentads each year, whilst those who wished to participate but lacked sufficient bird identification skills were encouraged to join experienced birders and work towards atlasing independently. A core group of 17 atlasers formed, along with several occasional participants. Van Rooyen communicated extensively with core members, detailing which pentads needed to be surveyed each month. Atlasers then selected and volunteered to survey pentads in each season and were updated continuously on progress towards achieving monitoring targets. Participation remained voluntary and locally organised, and participants were free to back out if or when desired (van Rooyen, personal communication).

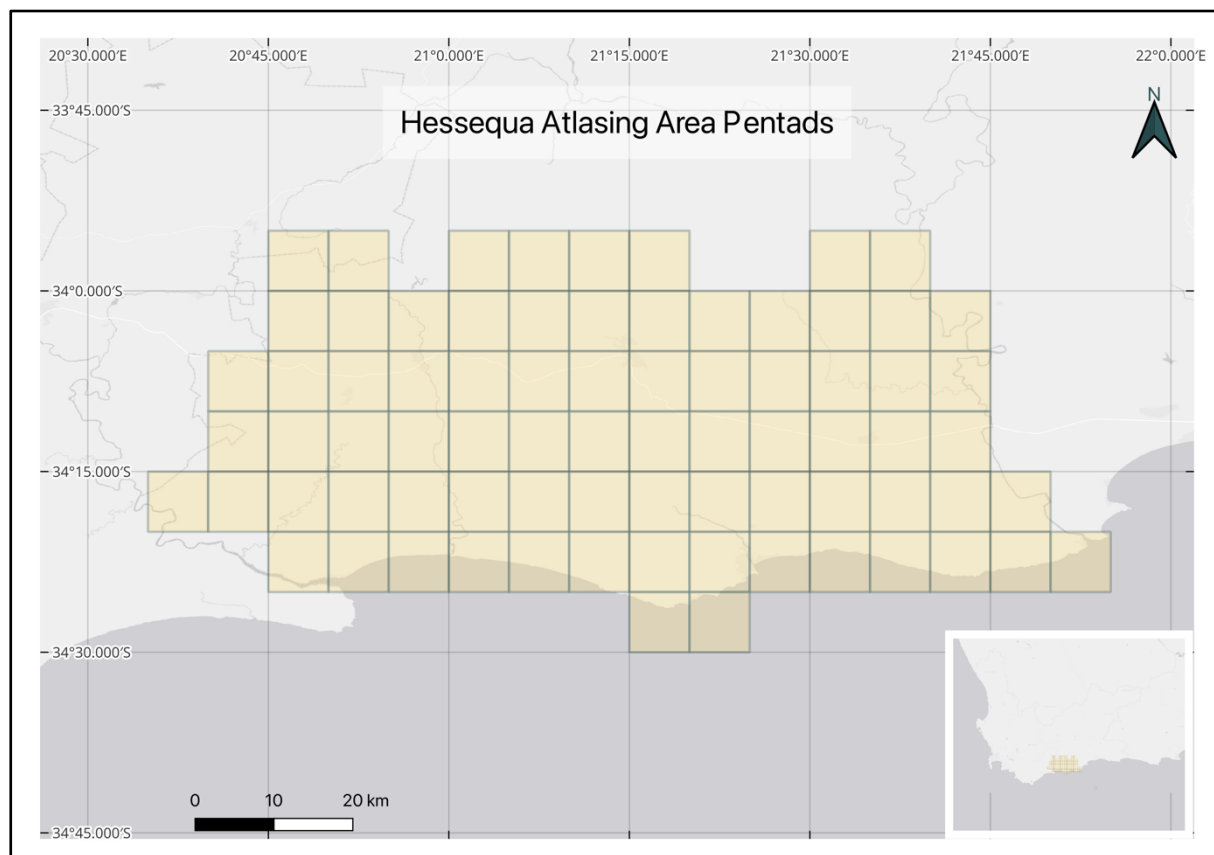


Figure 1. SABAP2 pentads comprising the Hessequa Atlasing Area in the Western Cape, South Africa.

The Hessequa project shows a monitoring initiative rising from within a community, leading to connections and communication between citizen science participants and local scientific professionals, and directly altering the resolution and potential conservation value of the data generated. Hessequa, therefore, is an ideal case study for understanding aspects of democratic knowledge production and dissemination in an African Bird Atlas Project, as well as for exploring the subsequent impacts of project co-creation on data quality. Thus, the Hessequa atlasers and their monitoring data are a primary focus of Chapters 3, 4, and 5.

Inclusive interventions: Values as indicators of meaning

Just as for democratic knowledge production and dissemination, the role of the African Bird Atlas Project (and atlases in general) towards supporting human-inclusive conservation interventions remains largely unexplored. Though a few studies have examined the motivations and experiences of participants (Wright et al. 2015; Rose et al. 2020), none have yet attempted a discussion of values. Values are critical components of social-ecological systems, expanding consideration of the human individuals and communities within ecosystems, and they have been described along numerous axes (Jepson & Canney 2003; Manfredi et al. 2020; Taylor et al. 2020; Mikołajczak et al. 2023). I focus here on the three value categories proposed in the 2015 IPBES Conceptual Framework: Instrumental, intrinsic, and relational (Díaz et al. 2015; Figure 2). Broadly, these may be understood as three different streams of meaning in human-nature interactions.

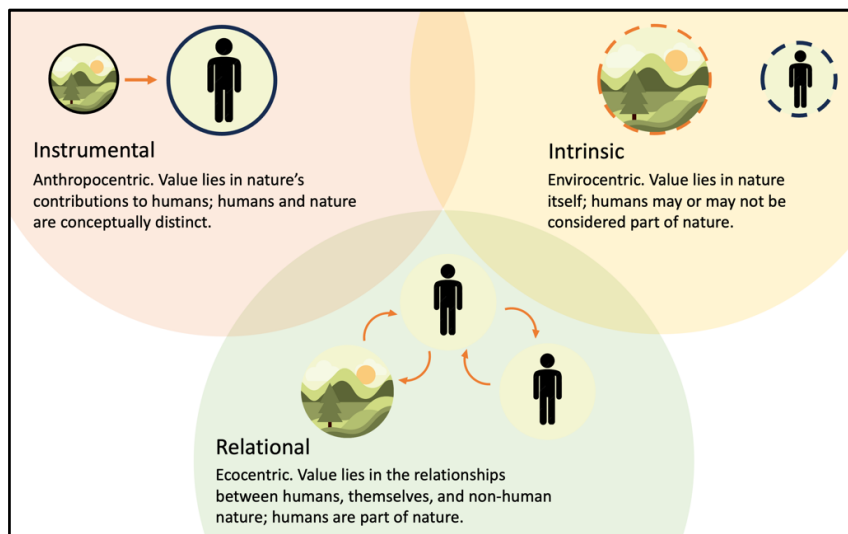


Figure 2. IPBES value categories between humans and non-human nature. Size reflects the focus of the value system. Arrows depict movement of value, orange indicates where value is held. Borders indicate integration or separateness of humans and nature.

Instrumental values

Instrumental values comprise perhaps the most intensively studied of the three IPBES categories and have a long history in ecological research (Westman 1977; Kaufman 1980; Parsons et al. 1994). These are values situated in economic understanding, based on an assumption of human preferences and an individual's willingness to "pay" in some form to indulge their preferences (Turner 1999). Thus, instrumental values encompass all manner of tradeable valuations of nature. Perhaps most notably, they include the ecosystem

services concept (Ehrlich & Mooney 1983; Daily & Matson 2008; Adams 2014) and, more recently, nature's contributions to people (Díaz et al. 2018; Kadykalo et al. 2019; Hill et al. 2021). While acknowledging that the "services" rendered by nature are important components of social-ecological systems, many scientists have argued against the inherent anthropocentrism of ecosystem services evaluations (Davidson 2013), citing these as narrowly utilitarian in focus and incapable of sustaining biodiversity in the long term (Turnhout et al. 2012; Schröter et al. 2014; Kenter 2018; Muradian & Gómez-Baggethun 2021; Piccolo et al. 2022). The term 'nature's contributions to people' emerged to build on and expand the focus of the ecosystem services perspective to incorporate both the positive and the harmful contributions of non-human nature towards human quality of life (Kadykalo et al. 2019), and has been praised for creating space for a greater variety of the important human dimensions of conservation, such as cultural inclusivity (Satterfield et al. 2013; Fish et al. 2016) and Indigenous and local knowledge (Díaz et al. 2018; Kadykalo et al. 2019). Both ecosystem services and nature's contributions to people describe humans and nature as conceptually distinct (Figure 1), and the extent of their anthropocentric orientation is contested by scientists (e.g. Díaz et al. 2018; Kenter 2018). Still, instrumental valuations of non-human nature remain prevalent both within scientific literature and, increasingly, policy (e.g. Jack et al. 2008; Braat & de Groot 2012; Greenhalgh & Hart 2015; McElwee et al. 2020). Thus, the study of instrumental values brings an important yet incomplete understanding of the value exchanges between humans and non-human nature.

Intrinsic values

Intrinsic values have been a prominent component of conservation since its inception (e.g. Muir 1916). The premise of these values was eloquently described by Soulé (1985): "*Species have value in themselves, a value neither conferred nor revocable, but springing from a species' long evolutionary heritage and potential or even from the mere fact of its existence.*" As Soulé also presciently intuited, intrinsic values have become a much-debated topic in the fields of conservation, environmental philosophy, and ethics. Critics have questioned the practicality of using intrinsic values as leverage points, as individuals are unlikely to base decisions around something's inherent worth (Maguire & Justus 2008; Chan et al. 2016). Proponents, however, claim intrinsic values as a vital aspect of conservation and moral action: "*In the same way that we need not reframe the discussion about equality of all humans because not all slavery in the world has ended, we need not necessarily reframe our concept of intrinsic value in nature because we have yet to accomplish a comprehensive conservation of biodiversity*" (Piccolo 2017). This argument places intrinsic value at the centre of a conservation ethic, contending that the commodification of non-human nature (i.e. instrumental valuation) cheapens their worth and makes them vulnerable to losses in favour of supporting human wellbeing (McCauley 2006; Doak et al. 2014; Miller et al. 2014; Vucetich et al. 2015; Piccolo 2017). Importantly, intrinsic values are associated with a sense of moral duty towards non-human nature, which may serve as a precursor for conservation action (Lan et al. 2022).

As the body of values literature grows, it is increasingly apparent that the feud between instrumental and intrinsic value systems is based on a false dichotomy (e.g. Armsworth et al. 2007; Justus et al. 2009; Tallis & Lubchenco 2014). Both systems offer necessary perspectives regarding meaning in non-human nature, and both share an underlying goal of enhancing conservation action (Klain et al. 2017). Rather than reducing ecosystem

values to one term or another, conservation is strengthened by embracing complexity, integrating key concepts from plural valuations of non-human nature (Klain et al. 2014; Arias-Arévalo et al. 2017; Gale & Ednie 2019; Martín-López 2021; Balvanera et al. 2022). This reality necessitated the inclusion of the third IPBES value category: Relational values.

Relational values

Relational values first arose as a concept to stretch beyond the dichotomy of instrumental and intrinsic valuations (Díaz et al. 2015; Muraca 2016; Chan et al. 2016, 2018). They describe the value of non-human nature existing not within utility or within entities themselves, but in relationships between the human and non-human individuals and communities within an ecosystem (Mattjissen et al. 2020). In shifting emphasis away from only what is valuable to humans, relational values address a fundamental weakness of instrumental valuation by situating meaning in connections and beginning to decentralise an anthropocentric conservation narrative. This shift also draws the focus of research away from the often-polarising line of questioning surrounding both instrumental and intrinsic valuations, moving from asking “what is of value?” to “how do humans find meaning in non-human nature?” (Stenseke 2018; Stålhammar & Thorén 2019). This value category has garnered praise for its scientific inclusivity, because untangling and understanding relational values requires extensive interdisciplinary discourse and sustained listening between scientists and non-scientists (Allen et al. 2018; Chan et al. 2018; Sanborn & Jung 2021). Though relational values do not reach explicitly into the concept of inherent worth (cf. intrinsic values), their focus on relationship does bring language to values of interdependence, reciprocity, kinship, and nature-based identity (Chan et al. 2016), all of which place humans as integrated components, if not integral components, of larger systems. The ability of relational values to inform understanding of meaning as well as strengthen connections with and between scientific and non-scientific communities makes them an ideal lens through which to explore questions of current conservation relevance.

Values and motivations: a complex interrelationship

Citizen science participant motivations have been well-studied internationally (e.g. Kragh 2016), but scientists have only recently begun to consider motivation in connection with values, and many of these studies have focused on ‘values’ as a single broad category in motivation (Maund et al. 2020; West et al. 2021; Levontin et al. 2022). In particular, the interactions between participant motivations and instrumental, intrinsic and relational values have not yet been explored. Within the context of citizen science, examining these well-conceptualised IPBES value categories offers insight into the types of values held by participants, and also affords an opportunity to probe the relationships between value categories and motivations. In the broader context of conservation, linking values to motivations provides understanding of how values may lead individuals to act on nature’s behalf—especially important to consider because motivations are not always reliable predictors of behaviour change (e.g. Thompson et al. 2023). Hence, the motivations and instrumental, intrinsic and (in particular) relational values underlying citizen science participant experiences of non-human nature are the primary focus of Chapter 5 of this thesis.

Incorporating values in conservation: Learning through conversations

Describing the values of individuals and groups participating in the African Bird Atlas Project serves to deepen existing understanding of how people relate to non-human nature, where in their ecosystems they find meaning, and, potentially, how they are prepared to act on nature's behalf. Yet the study of values is challenging—not only because of the inherent slipperiness of the concept, but also in the practicalities of collecting meaningful data. Evaluating concepts as complex as values requires the use of tools that make space for such complexity to exist. Conversational interviews have a long history in the social sciences and anthropological research as methods for understanding the human individual (Denzin & Lincoln 2000; Rubin & Rubin 2005; Potter & Hepburn 2012; Brinkmann 2022). Through conversation, interviewees are provided with questions to talk around, and are not restricted to 'yes' or 'no' answers but instead encouraged to share stories, experiences, and opinions (Hopf 2004; DiCicco-Bloom & Crabtree 2006; Alshenqeeti 2014). The importance of stories in conveying meaning is widely evidenced in scientific literature (Atkinson 1998; Brinkmann 2014; Anderson & Kirkpatrick 2016). Stories are a framework people use to make sense of the world, and people remember and share stories of what is meaningful to them (i.e., what is of value). Thus, conversations guided by carefully designed questions can yield rich value-laden responses (van den Born et al. 2018; Bearman 2019; Chapman et al. 2019). The narrative interview harnesses this potential through opening the interview with a question that elicits a story answer (Hopf 2004). To prevent endlessly discursive conversation, follow-up questions are provided, lending structure to the interview and enabling comparative analysis between individual interviews (Knox & Burkard 2009; Brinkmann 2014). This blended approach of narrative and semi-structured conversational interviewing is well suited to building an understanding of the values held by individuals within a community, and thus was utilised to collect the data explored in Chapters 3 and 5.

Studying value systems in African Bird Atlas Projects

Though multiple African Bird Atlas subprojects may offer insights into the values of citizen science participants, here, I focus on SABAP2 atlasers in Hessequa, South Africa, and NiBAP atlasers in Jos, Nigeria. As an actively growing initiative, NiBAP takes a unique community-centred approach to atlasing (Ringim et al. 2022). Conversations with NiBAP participants can enrich current understanding of participant motivations and values across the broader network of African Bird Atlas Projects—understanding which to date remains largely restricted to SABAP2 (e.g. Wright et al. 2015; Rose et al. 2020). Similarly, studying participant values in both NiBAP and SABAP2 can aid in identifying the values underpinning participant motivations. These insights can provide practitioners with practical guidance for shaping their projects around locally salient values in order to support data collection efforts and maximise participant benefits. For these reasons, interviews with SABAP2 and NiBAP atlasers form the basis of Chapters 3 and 5.

5. Research rationale and chapter summaries

Drawing on a social-ecological systems framework, this thesis seeks to describe the role of two African citizen science initiatives in meeting the three pressing challenges of contemporary conservation: Biodiversity monitoring, democratic participation, and inclusive intervention. In Chapter 2, I explore the contributions of citizen science to both biodiversity monitoring and the promotion of democratic and inclusive conservation. I

also discuss current challenges and shortcomings in the field of research. In Chapter 3, I focus on a community of SABAP2 atlasers in Hessequa, South Africa, and assess the impacts of a participatory community monitoring initiative on citizen science atlas data quality. Chapter 4 continues following the atlas community in Hessequa, using their data to detect trends in local species populations and discussing inclusive ways to apply and communicate results. Finally, in Chapter 5, I use a series of conversational interviews with the atlasers in Hessequa, as well as an atlas community in Jos, Nigeria, to describe the landscape of values expressed by citizen science participants and non-participants and explore links between relational values and motivations to participate in an atlas project.

Publication of chapters and co-authorship

The chapters of this thesis are intended for publication, and Chapters 3 and 4 are already published in international peer-reviewed scientific journals. Hence, there is some overlap in the material covered in this introduction and subsequent chapter introductions. As far as possible, Chapters 3 and 4 are presented in identical format to their published versions. However, I have made minor alterations to the wording in these chapters where it helps the reader to engage with the thesis as a single document rather than a series of standalone papers. When the remaining chapters are published, each will include as co-authors the individuals who have made substantive contributions to strengthening the chapters. All co-authors provided feedback on the chapters with which they were involved, in addition to any roles highlighted in Table 1.

Table 1. Contributions of co-authors for each of the five chapters of this thesis. Asterisk () denotes published article.*

Chapter	Title	Co-author	Contribution(s)
1	Introduction	Karis A. Daniel	
2	An overview of citizen science contributions to biodiversity monitoring and democratic conservation	Karis A. Daniel	
3	*Temporal dimensions of data quality in bird atlases: the case of the Second Southern African Bird Atlas Project	Karis A. Daniel Les G. Underhill	Assistance with data analysis
4	*Bird atlas in action: Using citizen science data to generate population trend alerts in Hessequa, South Africa	Karis A. Daniel Les G. Underhill Johan A. van Rooyen	Assistance with data analysis Leadership and coordination of Stilbaai Bird Group
5	The human dimensions of citizen science: Assessing participant relational values in two African Bird Atlas Projects	Karis A. Daniel Sina Vargas Madrid Jacqueline Loos Talatu Tende Johan A. van Rooyen Les G. Underhill	Assistance with interview coding and analysis of Nigeria dataset Provision of values framework Coordination of Jos interviews Coordination of Hessequa interviews Assistance with data analysis

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CHAPTER 2

An overview of citizen science contributions to biodiversity monitoring and democratic conservation



If citizenship is a matter of shared beliefs, then I believe in the democracy of species. If citizenship means an oath of loyalty to a leader, then I choose the leader of the trees. If good citizens agree to uphold the laws of the nation, then I choose natural law, the law of reciprocity, of regeneration, of mutual flourishing.

Robin Wall Kimmerer
'Braiding Sweetgrass'

1. Introduction

Emerging from what Maxwell et al. (2020) describe as “*decades of underwhelming responses to the global biodiversity crisis*,” conservation science faces a paradigm shift. The United Nations (UN) Sustainable Development Goals, the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES 2019), the Convention on Biological Diversity (CBD) Kunming-Montreal Global Biodiversity Framework (CBD 2022), and the Essential Biodiversity Variables concept (Pereira et al. 2013) all challenge past approaches to biodiversity conservation, emphasising a need to monitor changes in biodiversity at multiple spatial and temporal scales and calling for inclusive, collaborative, and democratic methodologies. Citizen science has gained a foothold in conservation as a tool for improving both data collection and civic engagement in the sciences (Kobori et al. 2016; McKinley et al. 2017; Turrini et al. 2018; Adler et al. 2020; Fraisl et al. 2020, 2023). Broadly defined as volunteer involvement in scientific research (Hecker et al. 2018), citizen science employs large, widespread volunteer networks to increase the amount and speed of data collection as well as a project’s spatial scale (Dickinson et al. 2010). Technological advances have also increased accessibility, allowing non-scientists to collect and store precise, detailed species and location data (Haklay 2012; Catlin-Groves 2012; Vayena & Tasioulas 2015; Cavalier & Kennedy 2016; Lukyanenko et al. 2019). These characteristics of citizen science imply that it can be successfully leveraged in confronting the major challenges facing conservation; indeed, it has demonstrably aided efforts to understand species movements and distributions (Araujo et al. 2016; Walther & Kampen 2017; Weisshaupt et al. 2020; Cutajar et al. 2022; Hughes et al. 2022), relationships between phenological and environmental changes (Mayer 2010; Hurlbert & Liang 2012; Ellwood et al. 2017), and invasive species expansion (Delaney et al. 2008; Kobori et al. 2016; Walther & Kampen 2017; Johnson et al. 2020). Additionally, several studies have highlighted the potential of citizen science for increasing public scientific awareness, literacy, and engagement surrounding conservation issues (e.g. Crall et al. 2012; Toomey & Domroese 2013; Haywood et al. 2016; Turrini et al. 2018; Lüsse et al. 2022). However, these potentials are tempered with frequent criticisms of citizen science project design, data quality, ethicality, and exclusivity. Here, I review the broad-scale contributions of citizen science to biodiversity monitoring, democratic participation and inclusive interventions. I highlight current critiques and shortcomings and discuss opportunities for growth in applying this tool in research.

2. Citizen science and biodiversity monitoring: success stories

Monitoring changes in biodiversity is a necessary priority for conservation; so much so that the IPBES lists as one of its primary objectives to “perform regular and timely assessments of knowledge on biodiversity” (2019). These assessments, however, require high quality data at multiple spatial and temporal scales to support research. To describe the data needed for monitoring, Pereira et al. (2013) proposed a set of Essential Biodiversity Variables which constitute the baseline measurements needed to accurately characterise and respond to biodiversity change. Citizen science is particularly well-suited for collecting these variables, namely because it facilitates data collection in quantities and at geographic scales necessary for monitoring (Theobald et al. 2015; Chandler et al. 2017; Pocock et al. 2018). The amount of data collected by citizen science participants far exceeds anything achievable by professionals alone; for instance, projects such as eBird (Sullivan et al. 2009), the Breeding Bird Survey (Harris et al. 2020), and the African Bird Atlas Project (birdmap.africa) generate millions of records of species occurrence annually and approach nation-wide spatial coverages.

Internationally, citizen science already supports monitoring efforts for several taxa (Cigliano et al. 2015; Fraisl et al. 2020; Cretois et al. 2020; Koffler et al. 2021; Cutajar 2022; Stuber et al. 2022; Sipe et al. 2023).

3. Citizen science, democratic participation and inclusive interventions

Beyond monitoring data, citizen science may also contribute to broader conservation goals of democratising participation and crafting inclusive interventions. As the conservation landscape shifts to incorporate local and Indigenous knowledges, two priorities arise: Knowledge should be collective in its generation, and in its dissemination. It should incorporate diverse and numerous individuals and be equally accessible to all—scientist and non-scientist—affected by the challenges of biodiversity loss within social-ecological systems (Cornwell & Campbell 2011; Gavin et al. 2015; Druckman 2022; Fraisl et al. 2022; Köthe et al. 2022). Such democratisation of participation in the scientific process enables more of the people affected by biodiversity loss to be informed and involved in conservation. Democratic participation, in turn, can lend itself to crafting inclusive interventions that seek to consider and incorporate human ecosystem inhabitants as vital ecosystem components.

Although these requirements are not inherently met by every citizen science initiative, well-structured projects are able to do so. Through processes alternately referred to as community science or collaborative, co-created, or participatory citizen science, scientists and non-scientist community members work together on elements of project design, data collection, and in some cases data analysis (Bonney et al. 2009; Shirk et al. 2012; Haklay 2012; Eitzel et al. 2017; Albert et al. 2023). These integrated approaches to knowledge production have garnered praise from multiple disciplines for their inclusivity and collaborative nature, and in several instances have led to increases in local scientific literacy (Trumbull et al. 2000; Brossard et al. 2005; Dibner & Pandya 2018; Clement et al. 2023), broader public awareness of local conservation issues (Jordan et al. 2011; Johnson et al. 2014; Haywood et al. 2016), and a greater inclination to act on behalf of local species and habitats (Oberhauser & Prysby 2008; Crall et al. 2012; Adler et al. 2020; Carson et al. 2021). Studies have also demonstrated that participants report increases in environmental agency (understanding of the self as an actor in the ecosystem) when involved in data quality control and analysis and in sharing results (Fleming et al. 2015; Ballard et al. 2017; Harris & Ballard 2021; Hadjichambi et al. 2023). In these applications, the knowledge and literacy benefits of citizen science participation become important factors in empowering community members to make informed decisions regarding the ecosystems they inhabit (Strain et al. 2019; Agnew et al. 2022). As a result, some initiatives have sought to democratise knowledge dissemination by incorporating data feedback loops into project design, which require practitioners and citizen science participants to regularly discuss the objectives, methodology and applications of their project (e.g. Ramirez-Andreotta et al. 2015; Moustard et al. 2021).

Involving community members in citizen science also offers opportunities to understand local conservation issues more complexly through studies involving citizen science participants (Irwin 1995; Calabrese Barton 2012; Phillips et al. 2019; Kelly et al. 2019). As data collectors for conservation science, citizen science practitioners can contribute towards inclusive interventions by examining the values of their participants. These explorations can strengthen a project by alerting practitioners to the values underpinning participant motivations, enabling them to adapt management to support participants whilst also strengthening existing

motivations to improve data collection efforts (see Chapter 5). Conservation scientists also benefit from this understanding of citizen science participants by gaining insight into the broader values and local knowledge of environmental actors within a social-ecological system (Tauginienė et al. 2020; Diprose et al. 2022). The values of community members can point conservationists toward what is considered important within the community, guiding the creation of interventions tailored to local needs. Incorporating the values of local people—in this case, citizen science participants—as rights-holders and not only stakeholders (e.g. Kothari et al. 2013; Nelson et al. 2021) is an important step in turning democratic participation into inclusive intervention. Notably, interventions based on community values are “stickier” than those based solely on the values of scientists; because they hold more meaning and thus carry greater importance to individuals, they are more likely to persist (Danielsen et al. 2005; Danielsen et al. 2010; Kothari et al. 2013; Robinson & Sasu 2013; Franks & Schreckenberg 2016). Coupled with participatory project structure, an exploration of community values can bring non-scientists deeper into the thought, design, and implementation processes for a site-specific monitoring project, and can aid in channelling results into practical local application (Danielsen et al. 2005; Cigliano et al. 2015; Gavin et al. 2015; Pettibone et al. 2018).

4. Criticisms against citizen science

Alongside its widespread appeal for reaching monitoring targets and democratising participation in science, citizen science has received censure regarding weak project structure, poor data quality, unequal knowledge integration, exclusivity, and unethical perceptions of participants (Kremen et al. 2011; Roy et al. 2012; Lukyanenko et al. 2016; Chesser et al. 2019; Adler et al. 2020). To better understand their implications for research, it is worth exploring each of these criticisms in turn.

Problems of citizen science project structure and data quality

Project design remains a contested topic in citizen science; critics argue that opportunistic data collection produces data of inferior quality to hypothesis-driven research (Kosmala et al. 2016; Tiago et al. 2017). This is usually attributed to the spatial and temporal biases inherent in volunteer distribution and sampling effort—biases which could hold serious implications for fine-scale monitoring objectives. However, some studies have generated accurate species distribution models in spite of bias by using models which account for variations in observation process (e.g. Higa et al. 2015). Furthermore, research examining the underlying cause of spatial bias in citizen science data collection has implicated study design complexity, and not only observer distribution and effort, in generating bias (Geldmann et al. 2016; Tiago et al. 2017). Topography also compounds this effect: One study found that ease of landscape accessibility explained sampling effort bias, with rugged terrain yielding fewer submissions than readily accessible landscapes (Mair & Ruete 2016). Yet another study found relationships between observer expertise and sampling location, with more experienced observers tending to visit more natural habitats whilst novice observers sampled less natural (i.e. urbanised) habitats (Guetté et al. 2022). In this case, inconsistencies in observer sampling may complement each other and result in more comprehensive project coverage. Alternatively, problematic differences may be remedied through project design; for instance, implementing gamification strategies (built-in structured data collection incentives) can help to diminish bias by encouraging volunteers to visit data-poor regions, effectively increasing spatial

evenness in the dataset (Bowser et al. 2013; Xue et al. 2016; Ainsley & Underhill 2017; Heinisch et al. 2021). Structured protocols have also been used successfully in a number of citizen science initiatives to mitigate spatial and temporal bias and are increasingly accepted as producing data of sufficient quality for analysis (Kelling 2019; Balázs et al. 2021; Stuber et al. 2022; Daniel & Underhill 2023).

Communication and continued relationship between citizen science participants and practitioners can also be powerful tools in reducing both spatial and temporal bias in datasets (e.g. Richter et al. 2018). Scientists can identify priority areas and coverage gaps and incorporate these into advisory feedback, providing guidance for participants on where, when and why their data will be most valuable (e.g. Domingo-Marimon et al. 2022). The importance of communication is also highlighted in research from Thompson et al. (2023), who found that citizen science participants were eager to change the ways and places in which they collected data in order to mitigate potential sampling biases. Practitioners must remember that generating meaningful data is an important motivator for many citizen science participants (Frensley et al. 2017; Day et al. 2022; Kuehn et al. 2022; von Gönner et al. 2023; Daniel & Underhill 2023), and that strong interpersonal relationships and clear feedback may go a long way towards minimising the effects of spatial bias in opportunistic data.

In addition to spatial and temporal bias, claims of observer error are frequently levied against citizen science. The handful of studies examining these claims, however, have not found substantial variation between volunteer and professional performance in data collection tasks; observed differences typically involve instances of oversight, with professionals recording a few individuals which remain undetected by volunteers (Dickinson et al. 2010; Moyer-Horner et al. 2012). Oversight also becomes less pronounced among experienced volunteers, suggesting that observer learning and skill increase with practice and time involved in a project (Crall et al. 2011; Lewandowski & Specht 2015). Training, group collaboration, standardised sampling protocols, and expert verification may also reduce observer error (Dickinson et al. 2010; Griffiths-Lee et al. 2023). An alternative and developing approach suggests that definitions of data quality should transcend conformity to scientific standards, as non-scientist volunteers are able to approach challenges in unique ways and may offer valuable insights as questions or novel observations (Kennedy 2016; Lukyanenko et al. 2016). From this perspective, volunteer inexperience may be seen as increasing data quality; however, utilisation of this approach heavily depends on project goals. In favour of increased non-professional participation in project design, this approach may compromise the value of a single, scientifically-informed protocol as a starting point. There is little possibility of successfully achieving, for instance, a national bird atlas, unless a uniform protocol is established and adopted by all participants.

Challenges to democratic citizen science: Knowledge integration, exclusivity, ethicality

The problem highlighted above illustrates perhaps the greatest challenge facing citizen science as a democratic discipline: The integration of non-scientific knowledges. Whilst pursuing inclusivity, citizen science projects must also maintain a level of standardisation in protocol in order to generate useable data. In seeking this balance, citizen science has received criticism from sociologists for employing top-down structure, i.e. imposing a fieldwork protocol on participants and thus preventing full community ownership of projects (Tyfield et al.

2017). These criticisms are not without merit; citizen science practitioners must grapple with how to intentionally incorporate a plurality of knowledges into protocol design whilst producing scientifically valuable results (Jolibert & Wesselink 2012; Danielsen et al. 2018). Democratic participation, in the context of citizen science, requires knowledge integration to be a two-way street in which scientists are learning from non-scientists while also sharing the reasoning behind a standardised protocol and scientific method (Berkes 2009; Tengö et al. 2014; 2021; Wheeler et al. 2020). This dual-learning approach eschews “science done to” a population in favour of “science with,” and its effectiveness is backed by evidence emerging from several co-created citizen science initiatives (Kongo et al. 2010; Herrmann et al. 2014; Gérin-Lajoie et al. 2018; Alvarado et al. 2021; Senabre Hidalgo et al. 2021).

Closely tied to knowledge integration is the problem of demographic exclusivity in citizen science. While some progress has been made towards achieving equal representation in citizen science projects, it is still far from enough. Within the socio-political sphere, scientific disciplines are criticised for taking up a rhetoric of public engagement and democratic science without actually implementing meaningful changes (i.e. Woolley et al. 2016; Weingart et al. 2021; Cooper et al. 2021; Hadjichambis et al. 2023). For instance, studies indicate that despite utilising a language of equal participation and knowledge inclusion, many citizen science initiatives continue to reflect a traditionally socioeconomically empowered demographic and include few marginalised and minority individuals (Pandya 2012; Pateman et al. 2021; Potts et al. 2021; Paleco et al. 2021; Lewenstein 2022). This problem affects both ethics and practical application; if citizen science participants are to serve as effective community conservation advocates, they must be truly representative of a population. If, for instance, participants all share a particular socioeconomic status or educational background, their knowledge, values and priorities for conservation will not accurately reflect those of the wider community (Sorensen et al. 2019). In fact, using the perspectives of a non-representative subset of the population to inform policy may increase conflict between conservation practitioners and non-scientists, leading to an erosion of trust between scientists and non-scientists (Engen et al. 2019).

As with knowledge integration, this imbalance may be addressed through project design; as noted by Sorensen et al., initiatives seeking to increase inclusivity should “provide opportunities for communities to define, investigate, and address pressing issues in collaboration with professional scientists” (2019). To achieve this, inclusive citizen science projects lower barriers to participation for members of marginalised and minority groups (Cooper et al. 2021). Barriers are numerous and complex, ranging from lack of leisure time, transportation, and equipment, to limited access to collection sites and non-familiarity with scientific projects and protocols (Groffman et al. 2010; Chesser et al. 2019; Daniel 2021, unpublished data). For existing initiatives, there is potential to address these challenges with experienced participants, encouraging those who are able and willing to offer ride shares, equipment loans and mentoring where possible. Along with bringing marginalised groups into citizen science, these social partnerships are critical components of learning; multiple studies demonstrate the importance of social learning between citizen science participants and non-participants in bringing conservation awareness and literacy to broader communities (Johnson et al. 2014; Cigliano et al. 2015; Haywood et al. 2016; Richter et al. 2018; Day et al. 2022). Projects could capitalise on this impact by incorporating social learning as an objective and not only a by-product of participation, enlisting participants as

ambassadors in bridging communication gaps between scientific and non-scientific communities. Thus, with intentional project design, citizen science participants may increase both the democratisation of knowledge production, by involving diverse individuals in its creation, and knowledge dissemination, by communicating results and generating conservation awareness among non-scientific community members.

Lastly, the attitudes of conservation practitioners bring cause for concern, with studies implying that many scientists are biased against citizen science data or are suspicious of their utility in research (Geoghegan et al. 2016; Burgess et al. 2017). A second bias also exists, wherein scientists focus exclusively on the data collected by participants and limit consideration of participants themselves. These ethical problems reveal a persisting power dynamic, with certain members of the scientific community believing their knowledge and capability to be superior to participants and therefore viewing participants as a means to an end rather than as rights-holders with valuable scientific and non-scientific knowledge contributions (Petts & Brooks 2006; Gunnell et al. 2021; Pelacho et al. 2021). Confronting these challenges requires that scientists acknowledge the implications of their own biases: Mistrust of citizen science participants and their data may lead to feelings of despondency and resentment among participants; likewise, a solely data-driven approach may instil feelings of exploitation and non-inclusion (Lowry & Stepenuck 2021; Hunter et al. 2022). Failure to consider and honour the personhood and legitimate contributions of participants also threatens participant motivation; recall that generating meaningful data is an important motivator for many participants (cf. Problems of citizen science project structure and data quality). Moreover, there is a risk of compounding existing barriers of mistrust and weak communication between scientists and non-scientists (Kloetzer et al. 2021; Lowry & Stepenuck 2021), and these cycles of poor communication and mistrust ultimately compromise the potential efficacy and ethicality of projects.

However challenging, the complex sociocultural dimensions of citizen science are not necessarily cause for despair; indeed, their exploration is proving valuable in transforming a damagingly narrow scientific culture. As noted by Haklay (2012), “*This might end up being the most important outcome of citizen science as a whole, as it might eventually catalyse the education of scientists to engage more fully with society*” (p. 119). Trust between practitioners and participants can develop through the intentional co-creation of a project (Cigliano et al. 2015; Graham & Taylor 2018; Gérin-Lajoie et al. 2019; Walker et al. 2020). Specifically, co-created projects that employ a blended emphasis on both data quality and collection and participant engagement and fulfilment produce more meaningful data and feelings of empowerment for participants (Ramirez-Andreotta et al. 2015; Frensley et al. 2017; Clement et al. 2023).

5. Inclusive monitoring for biodiversity: a way forward

The potential for citizen science in biodiversity monitoring and democratic science can be considered among the discipline’s greatest strengths, serving to engage the people most affected by local changes in collecting data that will ultimately inform their own governance. Done well, citizen science has powerful implications for both biodiversity conservation and truly democratic and inclusive conservation outcomes, and may improve the resilience of social-ecological systems in response to change (Tidball & Krasny 2012; Gavin et al. 2015; Danielsen et al. 2021; Oliver et al. 2023). Though the discipline faces numerous challenges, many of these can

be remedied through evaluation of project structure, priorities and participants. To mitigate the effects of spatial, temporal and observer bias, citizen science practitioners can carefully consider data collection protocols, maintain consistent feedback and communication streams with participants, and where necessary, provide training and social learning opportunities to improve observer accuracy. To promote democratic participation in knowledge generation and dissemination, initiatives can intentionally identify and reach out to individuals who fall outside of the typical participant demographic and channel their knowledge and values into creating inclusive and impactful projects. For extant projects, both objectives may be achieved through taking inventory of community member and citizen science participant demographics, values and knowledge, and re-imagining data collection and applications to incorporate their diverse perspectives.

Despite the increasing prevalence of citizen science in ecological research, uncertainties still surround multiple aspects of its roles in biodiversity conservation and in society (Riesch & Potter 2014; Aceves-Bueno et al. 2017; Lukyanenko et al. 2019; Fritz et al. 2019; Adler et al. 2020). Though there is general consensus in the scientific community that citizen science adds value to the field of ecology, the full range of its potential contributions to biodiversity monitoring and democratic science remain incompletely understood (Bonney et al. 2014; Bela et al. 2016; Heigl & Dörler 2017). In continental Africa, the contributions of citizen science projects such as the African Bird Atlas Projects towards biodiversity monitoring are well-documented (e.g.). However, the contributions of these projects towards promoting democratic participation in scientific research and crafting inclusive local interventions have yet to be studied.

In the following three chapters, I endeavour to bring these recommendations to life through examining two citizen science initiatives, both branches of the African Bird Atlas Project network. Through a careful analysis of the project goals and structure in a citizen science participant community in South Africa, I examine the quality of the data collected by participants and how it can be improved and applied in practical interventions. Next, through a series of interviews with citizen science participants and non-participants in two communities in South Africa and Nigeria, I examine the values of the people involved in citizen science initiatives and affected by local biodiversity loss. I question the relationships between participation, values, and motivations to participate, providing project practitioners with a deeper understanding of the human dimensions of these two social-ecological landscapes.

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CHAPTER 3

Temporal dimensions of data quality in bird atlases: the case of the Second Southern African Bird Atlas Project



*The truth is always stranger, more lively and more expansive
than anything we can compute.*

James Bridle
'Ways of Being'

Abstract

Halting biodiversity loss on land (Sustainable Development Goal [SDG] 15) is an unfolding problem, and as such, requires novel solutions. Citizen science (CS) promises large quantities of data, but introduces the challenge of ensuring these are valuable to conservation research and can inform meaningful action. This paper contributes to this endeavour, examining the impact of systematic as opposed to unstructured fieldwork on the biodiversity monitoring value of data from the Second Southern African Bird Atlas Project (SABAP2). SABAP2 “atlasers” work within a fine-scale grid system to generate avian species checklists that are comprehensive at the time of fieldwork. Though valuable, unstructured fieldwork efforts paint an incomplete picture; effective conservation action requires monitoring—keeping a finger on the pulse of local biodiversity through consistent and systematic data collection. Systematic collection allows for the detection of nuanced biological patterns such as seasonal population trends and movements, rapidly alerting scientists to anomalies and galvanising swift response. It is, however, a demanding protocol, and implementation requires careful consideration of participant impact and motivations. Here, we used a newly developed approach for measuring temporal data quality to examine the systematic atlasing efforts of a CS community in the Hessequa Atlasing Area, South Africa, assessing the biodiversity monitoring value of structured data collection versus opportunistic checklists. We found that structured data collection increased the temporal resolution of atlas data, and thus its monitoring quality. We discuss challenges in maintaining achievable fieldwork goals for participants, and examine Hessequa’s project structure and participant motivations to provide recommendations for future project management.

1. Introduction

Conservation is context-dependent; novel problems require novel solutions, and the analysis of citizen science (CS) data is no exception. As technological advancements rapidly expand the field of CS, scientists are faced with previously unmatched quantities of raw data at unprecedented scale, and are tasked with learning how to utilise these to maximise their potential conservation impact. While the scientific value of CS data rests in whether they are amenable to statistical analysis and able to generate defensible scientific outputs, it is equally important to consider the sociocultural value of CS and the impact of a CS initiative on its participants. In this study, we seek to further discussions on both concepts.

Citizen science and confronting biodiversity loss

Among the 17 Sustainable Development Goals (SDGs) outlined by the United Nations (UN), SDG 15 sets a target of halting biodiversity loss. Recent outputs from The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Convention on Biological Diversity (CBD) Kunming-Montreal Global Biodiversity Framework draw attention to a widespread need for the involvement of “the whole of government and the whole of society” in combatting the global biodiversity crisis and achieving SDGs (CBD 2022). This spotlight on collective action arrives at an opportune moment, corresponding with a rise in scientific understanding and implementation of CS initiatives (Follett and Strezov 2015). CS as a discipline serves at least two purposes: It opens the door for public participation in scientific research (Bonney et al. 2009b) and amasses data in quantities and over spatial and temporal scales not achievable by scientists alone (Dickinson et al. 2010; Chandler et al. 2017). CS has already contributed towards the monitoring needed for achieving SDG targets (Fraisl et al. 2020); however, beyond data output, a collective action approach requires an equal consideration of the personal and social dimensions of CS participation (Bonney et al. 2009a,b; Phillips et al. 2019). What motivates citizen science participants to participate, and how can scientists support these motivations to ensure project sustainability? Such questions mark a movement away from viewing CS as crowdsourcing and towards exploring its broader potential; no longer only data collectors, citizen science participants are included as co-creators in project design, data analysis, and even policy implementation (Thornhill et al. 2019; Hidalgo et al. 2021). Targets identified in the Kunming-Montreal Global Biodiversity Framework also emphasise a need to understand the social and cultural implications of collective action; within the context of CS, we ask, what are the personal and community-level impacts of participation, and how do these contribute to social change?

Citizen science in southern Africa: SABAP2

Within southern Africa, long-standing contributory CS projects such as the Second Southern African Bird Atlas Project (SABAP2, <http://sabap2.birdmap.africa>) have generated vast quantities of valuable species distribution data and have served as subjects for an extensive body of research (Harrison et al. 2008; Hofmeyr et al. 2014; Underhill 2016; Burman et al. 2018; Lee et al. 2022). SABAP2 utilises a systematic, protocol-based collection methodology in which citizen science participants operate within a grid system to compile species checklists that are comprehensive at the time of fieldwork. Many aspects of the atlas are designed for ease of statistical analysis: It operates on a pentad scale (144 pentads per 1-degree square), a spatial unit which is five minutes north to south and five minutes east to west (roughly 9 km × 8 km) (Underhill 2016). This scale was carefully selected to balance manageable spatial coverage within a minimum two-hour protocol while producing fine-scale knowledge of

species presence (Underhill 2016). Participants are encouraged to explore each pentad as thoroughly as they can, searching for bird species in as many habitat types as possible. Once a pentad is populated with a small number of seasonal bird atlas checklists, all species that are regularly part of its avifauna are likely to be detected, and by default, the remainder of the world's avifauna are listed as "not occurring" regularly in the pentad. Hence, once data collection coverage is comprehensive, distribution maps produced by bird atlas data can be regarded as accurate.

Traditionally, bird atlas projects for a region have had time frames measured in years, with the goal of obtaining as complete coverage as possible within the project time period, which is frequently five years, as for the First Southern African Bird Atlas Project (SABAP1; 1986–1990) (Harrison et al. 2008). SABAP1 provided a snapshot of bird distributions for this time period. The Second Southern African Bird Atlas Project (SABAP2) launched in July 2007 and was initially intended to provide a similar snapshot that could be used for comparison with SABAP1. However, SABAP2 ultimately morphed into a long-term monitoring project, ongoing in 2022. At 15 years, it is the longest-running atlas project in the world; however, SABAP2 cannot be classed as a monitoring project because it does not employ the repetitive and regular fieldwork necessary for detecting trends through time (Tulloch et al. 2013). Paired with systematic fieldwork efforts, SABAP2 offers an opportunity to undertake long-term spatial monitoring at a sub-continental scale, providing critical baseline data necessary for understanding changes in local avian biodiversity (Boakes et al. 2010; Pocock et al. 2018; Altwegg & Nichols 2019). This paper describes a fieldwork strategy that has already been trialed, and discusses this strategy from two perspectives: (1) the quality of data it generates, and (2) sustainability in terms of human resource management, leadership, and motivation.

Temporal proximity as a measure of conservation relevance

Though fine-scale species lists are excellent resources, their value to applied conservation is mediated by recency. Biodiversity monitoring requires constant database refreshing to ensure that any action taken will be relevant at the time of implementation (Tessarolo et al. 2017); high-resolution temporal data are necessary for detecting population trends (Dennis et al. 2017; Horns et al. 2018; Fink et al. 2020), analysing phenology (Mayer 2010; La Sorte et al. 2014; Supp et al. 2015; Bison et al. 2019), detecting invasive species (Pocock et al. 2017; Grason et al. 2018; Moulin 2020), and examining detection probability (de Solla et al. 2005). In this regard, SABAP2 pentads with recent checklists are of greater value than pentads with old checklists (Callaghan et al. 2019). SABAP2 checklists, however, remain opportunistic, since pentads are not necessarily atlased with regularity, and the relevance of data from a given region corresponds directly to the collection efforts of local citizen science participants. This poses the challenge of obtaining data of monitoring value from a semi-structured CS protocol; along with other dimensions of sampling bias (Courter et al. 2013; Bird et al. 2014; Isaac et al. 2014; August et al. 2020; Di Cecco et al. 2021; Bowler et al. 2022), consistency of sampling effort remains a critical component in generating early warnings (Kamp et al. 2016; Brown & Williams 2019). We examine the potential for systematic fieldwork to address this challenge and improve the temporal resolution of regional SABAP2 data.

2. Materials and methods

Atlasing areas

Eleven atlasing regions were selected for comparison with the region of interest, Hessequa, on the basis of geography, comparable size, and atlasing effort (Table 1). Eight of these regions (GG1–8) fall within Greater Gauteng; an area defined as four one-degree grid cells that cover Gauteng Province as well as parts of Limpopo, North West, Mpumalanga, and the Free State (Ainsley 2016). The remaining three regions, Western Overberg, Garden Route, and Northern Swartland, are within the Western Cape. All eleven regions are roughly equivalent in size to Hessequa (75 pentads): each of the eight Greater Gauteng regions contains 72 pentads, Western Overberg contains 79 pentads, Northern Swartland contains 77 pentads, and Garden Route is the largest, containing 99 pentads.

It is important to note that additional data such as the number of atlasers and consistency of atlasing effort are not easily estimated for all of the eleven regions selected for comparison. Because Hessequa and the eight Greater Gauteng regions were part of intentional data collection challenges, we have a clearer knowledge of participation and effort in those regions during those challenges. However, apart from Hessequa, data collection efforts in all other regions remain largely uncoordinated, with no consistent motivational strategy in place (Table 1). In all regions with periods of intentional data collection, opportunistic checklists (i.e., full-protocol checklists completed by visitors and ad-hoc species records) were also accepted.

Hessequa Atlasing Area

The 75 pentads of the Hessequa Atlasing Area (Hessequa) closely follow the boundary of the Hessequa Municipality on the western edge of the Garden Route. The northern pentads of Hessequa are bordered by the Langeberg mountain range, and the southernmost pentads reach the sea. Though pentads in the north and south contain natural vegetation, the majority of Hessequa consists of agriculturally transformed land, used for both crops (barley, canola, wheat) and livestock farming (cattle and sheep).

Fieldwork efforts in Hessequa were erratic from the launch of SABAP2 in 2007 until 2014, when local atlasers began pursuing seasonal monitoring targets across two-year cycles (van Rooyen & Underhill 2020). The monitoring strategy began with a chessboard pattern for the region, dividing the atlasing year into four austral seasons: Summer (December—February), Autumn (March—May), Winter (June—August) and Spring (September—November). Over a two-year period, the black pentads of the chessboard received fieldwork in summer and winter during the first year and autumn and spring during the second year, and vice versa for the white pentads. In this way, every pentad was scheduled to produce a checklist in every season by the end of a two-year atlasing cycle, with structure to the patterning of the seasonality. This structure served to equalise observer effort across all pentads, mitigating potential biases across habitat types (e.g. Bowler et al. 2022).

Efforts were coordinated by Johan van Rooyen, leader of the local U3A Stilbaai Bird Group. Van Rooyen, a keen atlaser, introduced the idea of an atlasing project by hosting a trial atlasing day, dividing participants into six groups and sending each out with at least one experienced birder to compile a bird checklist in different parts of the same pentad (van Rooyen, personal communication). Van Rooyen explains the four groups together compiled

a list of more than 100 species, and those who enjoyed the experience committed to atlas-ing a certain number of pentads each year, while those who wished to participate but lacked sufficient bird identification skills were encouraged to join with experienced birders and work towards atlas-ing independently. A core group of 17 atlasers formed, along with several occasional participants. van Rooyen communicated extensively with core members, detailing which pentads needed to be surveyed each month. Atlasers then selected and volunteered to survey pentads in each season and were updated continuously on progress towards achieving monitoring targets. Participation remained voluntary and locally organised, and participants were free to back out if or when desired (van Rooyen, personal communication).

Greater Gauteng Regions

The four-degree area containing the eight Greater Gauteng regions (25°S 27°E northwest corner; 27°S 29°E southwest corner) has been extensively atlas-ed since the launch of SABAP2 in 2007. The four degrees are centred around the cities of Johannesburg and Pretoria and encompass a range of urban and peri-urban habitats. Regional atlas-ing efforts can be largely attributed to a collection of CS challenges initiated in the area; these included goals of atlas-ing each pentad in the four degrees once every year, and even once every month (Ainsley 2016). In 2016, focus shifted to a seasonal timescale, attempting to atlas every pentad twice in both summer and winter of each year (Ainsley & Underhill 2017). Though the eight regions continue to generate large quantities of data, coordination of atlas-ing effort was and remains minimal, and data collection cannot be considered systematic.

Northern Swartland

The Northern Swartland is a block of 77 pentads with 33°S 18°E in the northwest corner and 33°30'S 19°E in the southeast corner. Moorreesburg and Hopefield are the largest towns within the boundaries, and most of the land in the region is transformed to arable agriculture, with wheat and canola as primary crops. The western edge of the region contains the natural vegetation of the West Coast National Park. No coordinated atlas-ing or systematic data collection efforts have been implemented in the region.

Garden Route

The Garden Route consists of 99 pentads with 33°40'S 22°E in the northwest corner and 34°15'S 23°30'E in the southeast corner. It contains the land south of the Outeniqua mountain range, with Mossel Bay, George, and Knysna as its main population centres. Land cover varies from natural vegetation (ranging from Mountain Fynbos to indigenous forests) to commercial plantations and both arable and pastoral agriculture. No coordinated atlas-ing or systematic data collection efforts have been implemented in the region.

Western Overberg

The Western Overberg contains 79 pentads with 34°S 19°E in its northwest corner and 34°35'S 20°E in its southeast corner. The main towns within the boundaries are Caledon, Hermanus, and Gansbaai. The region is mostly transformed for agriculture, more arable than pastoral, with some tracts of natural vegetation (mountain fynbos and renosterveld). No coordinated atlas-ing or systematic data collection efforts have been implemented in the region.

Dimensions of data quality

The focus of this paper is a comparison of systematic fieldwork and non-systematic fieldwork, specifically in what ways the systematic fieldwork in Hessequa differs from non-systematic fieldwork elsewhere. While not all are explicitly discussed here, it is necessary to acknowledge some of the significant factors impacting CS data quality. Among others, these include four biases identified by Isaac et al. (2014): (1) uneven temporal intensity of records, (2) uneven spatial coverage, (3) uneven sampling effort per visit, and (4) variation in volunteer ability to detect species. Here, we examine only the temporal intensity, or “recentness” and spatial coverage of SABAP2 data in each of the eleven selected regions. Several studies have stressed the importance of structuring and monitoring a CS initiative’s data collection process to limit potential bias (Hugo & Altwegg 2017; Kelling et al. 2019; August et al. 2020; Di Cecco et al. 2021); the design of SABAP2 is intended to minimise uneven spatial and sampling bias as well as species misidentification. Gamification encourages atlasers to regularly visit both new and “home” pentads (Ainsley & Underhill 2017), and the strict collection protocol standardises fieldwork effort and limits participation to birders with strong identification skills. Though no dataset can be considered watertight, it is assumed that these elements of project design reduce potential variation in SABAP2 data (Bird et al. 2014; Kelling et al. 2019). Though the SABAP2 protocol addresses spatial, sampling, and detection biases, it does not fully address the problem of temporal quality; citizen science participants are under no obligation to refresh species lists in specific pentads (though this is encouraged). Thus, we limit the focus of our analysis to temporal quality.

Measuring temporal quality

Advocates of systematic fieldwork may reasonably expect that, across all pentads in a region, species occurrence records are, on average, more recent than with non-systematic fieldwork. For any one species recorded in a pentad, the critical date is its most recent record (Callaghan et al. 2019); as that date recedes farther into the past, the less likely it is that the species persists in that pentad. We first calculate the date of the most recent record for each species recorded in the pentad. This information is then summarised by calculating the median of these dates of the most recent record (we use the median date in preference to the mean date because it is a robust measure of the central point of the dates). This median date provides a simple summary of the recency of the species records for the pentad. Finally, we calculate the median of the median dates for all the pentads in the region. This date provides us with an estimate of the overall temporal quality of the bird atlas data for the region (Underhill, unpublished). This final date is then compared with the date on which the calculations were undertaken. This difference in dates, measured in days, is small if, overall, the records for species in the region are recent, and it is large if, overall, the records are old. We coin the term “temporal proximity” to describe this quantity. Thus, small values of temporal proximity indicate good data quality, and large values indicate poor quality. Again, it is important to note that these characterisations refer only to the temporal quality of data. For each region described above, we calculated temporal proximity at the end of each year from 2009 to 2021, using the SABAP2 data collected up to that point in time. Using the ggplot2 package (Wickham 2016) in R (R Core Team 2020), we plotted the values of this time series as a line graph for each region. Additionally, we calculated the number of

checklists submitted to the project in each year from 2009 to 2021 for each region; we plotted these as a histogram, with the colour intensity of the bars describing the percentage of pentads within the region visited in that year.

3. Results

In the Hessequa region, fewer than 80 checklists per year were submitted between the years 2009 and 2014 (Figure 1). At the end of 2012, the year with the smallest number of checklists, the temporal proximity was 730 days (Table 2). In other words, on 31 December 2012, the median of the 75 temporal proximities of the pentads within the Hessequa region was 730 days. From 2015 to 2021, the number of checklists for the region increased to between 200 and 300 per year (Figure 1), and the overall temporal proximity for the region improved to periods of between 127 and 244 days. The motivational strategy used by the leadership of the Stilbaai Bird Group resulted in every pentad being surveyed in every quarter; there were no gaps in the data. We discuss this aspect of project sustainability below.

By contrast, the Western Overberg, for example, mostly received between 200 and 300 checklists per year between 2009 and 2021; the temporal proximity shows a long-term deterioration from 113 days in 2009 to 967 days in 2021 (Table 2, Figures 1 and 2). Similar patterns of gradual deterioration in temporal proximity over the full 12-year span are apparent when comparing the remaining 10 regions with Hessequa (Table 2, Figures 2 and 3). The same pattern emerges when this analysis is performed on checklists for the austral spring (September to November) (Table 3, Figures 4, 5 and 6). At the end of 2021, of the 10 regions compared with Hessequa, only Greater Gauteng Region 4 (GG4) had a temporal proximity comparable with Hessequa (473 versus 403 days) (Table 3, Figures 7 and 8), even though the number of spring checklists submitted for GG4 far exceeded the number submitted for Hessequa (390 versus 59; Figure 5). The inescapable conclusion is that systematic atlasing in Hessequa significantly impacted the temporal proximity of data when compared with eleven thoroughly—but non-systematically—atlased regions (Tables 2 and 3). Additionally, the improvement in temporal proximity through systematic atlasing is achieved with far smaller amounts of fieldwork than in the other eleven regions (Figures 1, 4, 5 and 8).

4. Discussion

Temporal proximity as a measure of data quality

Apart from the illustrative examples in Underhill (unpublished), this is the first large-scale application of this method for quantifying the temporal proximity of a biodiversity database. Its behaviour in this application needs to be assessed. By design, temporal proximities are small when every pentad is visited regularly, as in the systematic fieldwork used in Hessequa. Our interest focused on the extent to which the algorithm would show large temporal proximities in the eleven areas where atlasing was non-systematic. It clearly achieved this (Tables 2 and 3, Figures 1–4). At face value, the large quantities of checklists (frequency exceeding 1,000 per year) submitted for the Greater Gauteng regions (Figure 5) would suggest that these regions have the best data; however, this is not necessarily the case. The approach of quantifying temporal proximity provides a more nuanced measure of the quality of biodiversity data than number of checklists alone.

SABAP2 started in July 2007, and the earliest date for which temporal proximity was calculated was 31 December 2009, 30 months later. At the start of a project, all records are recent, and the numbers of species per pentad is still increasing. Thus, temporal proximities in the early years will always be good, in spite of small volumes of data (Tables 2 and 3, Figures 1–4). A further consideration is that, in computing the temporal proximity at the end of each calendar year (Tables 2 and 3), the algorithm included all checklists submitted since the commencement of the project. The total species lists for each pentad slowly increased through time with the occurrence of vagrant species; thus, the temporal proximity for each pentad was computed across a steadily increasing number of species, at least some of which are unlikely to be observed again. To a large extent, the use of the median rather than the mean to compute the temporal proximity eliminates this problem, but it is important to acknowledge that temporal proximity will become larger over time, even with uniform amounts of fieldwork. This could be overcome by eliminating vagrant species from the calculations, but introduces subjectivity and arbitrariness into the measure. In Hessequa, by 2021, this appears to be a theoretical concern rather than a practical one; for the final four years, 2018 to 2021, the temporal proximity remained stable (Tables 2 and 3).

Exploring effective timescales

As well as maintaining temporal proximity, the Hessequa protocol was also designed around the capacity of atlasers to sustainably achieve the required level of fieldwork. In other areas with sufficient human resources available to undertake systematic atlasing, it would be worthwhile to test alternative strategies. Strategies that are less intense than the Hessequa protocol can be tested for their potential impact on temporal proximity by simulation. This would involve subsampling, in accordance with the proposed strategy, from the Hessequa database.

Generating meaningful data

A key challenge for biodiversity monitoring data is their ability to generate alerts while mitigation is still possible (Pocock et al. 2018; Altwegg & Nichols 2019). Early warning systems are necessary not only for detecting problems, but also informing response. Many comparisons of CS data are made over extended time periods, and within these timeframes, new and potentially irreversible threats may establish themselves. Examples include comparisons of changes in range and abundance between bird atlas projects, which typically take place at decadal intervals or longer. To date, the only study to consider trends within the timescale of the SABAP2 project rather than to make comparisons between SABAP1 and SABAP2 is Quintana et al. (unpublished); the authors describe a range expansion of the African Red-eyed Bulbul since 2007, when SABAP2 started. Though the authors present important insights, their trend comparisons are weakened by the reality that the atlasing protocol in place was non-systematic, and the pentads atlased in a given year were essentially random. In contrast, analysis of data from Hessequa demonstrates that the systematic records can be used to estimate trends in the abundance of the 165 most commonly occurring species in the Hessequa region (Chapter 4). Crucially, these data reveal that as a group, waterbirds experienced the largest short-term decreases in abundance between 2014 and 2021. These trends can now be closely followed to understand the severity and nature of declines. The ability to follow these fine-scale changes reflects important progress towards current targets in global policy; in particular, SDG 15, and the Kunming-Montreal Global Biodiversity Framework (CBD 2022). Halting biodiversity loss begins with understanding the current state of systems (Mehring et al. 2017; Hochkirch et al. 2021), and monitoring species at a regional scale generates a nuanced and up-to-date picture of population trends, seasonal changes, and shifts

in distribution. Systematic data collection initiatives not only address critical data deficiencies, but also generate data that are capable of telling a long-term story.

Participant benefit and the success of the Hessequa atlasing project

Our results demonstrate the feasibility of maintaining up-to-date and comprehensive atlas coverage with relatively few checklists. This realisation is especially significant in light of recent dialogue regarding participant benefits in CS (Kimura & Kinchy 2016; Adler et al. 2020); as CS becomes increasingly relevant to conservation work, scientists are met with the double-edged challenge of ensuring that participants are not exploited as free labour while also encouraging a level of fieldwork effort that will produce meaningful quantities of data (e.g., Robinson et al. 2018). Taken as a case study, the Hessequa initiative may offer insights into achieving sustainable fieldwork goals. Though numerous factors undoubtedly influence the project's success, here we discuss three: local leadership, communication/dissemination of scientific results, and community-structured protocol.

As part of the research for this thesis, 17 atlasers in Hessequa participated in semi-structured conversational interviews; these are explored in detail in Chapter 5. Comparison of citizen science participant motivations between atlasing regions in South Africa was not a focus of this thesis; thus, interviews were not carried out in any of the other eleven regions. The interview insights presented here are intended to enrich ongoing conversations around citizen science participant motivation and project impact, and are not intended for comparison with other atlasing regions or CS initiatives. In interviews, Hessequa atlasers were asked to discuss their motivations for participating in SABAP2. Though personal motivations varied between individuals, nearly all interviewees emphasised the role of their local project leader in maintaining their interest and motivation in the atlas project (see Chapter 5).

While participation in the Hessequa atlas project was voluntary, local project leader Johan van Rooyen (see van Rooyen 2018) used a variety of techniques to keep participants engaged and motivated. Atlasers were consistently updated via email on their collective progress towards achieving monitoring targets and were provided with detailed maps of the Hessequa Atlasing Area for use in the field. As an additional resource, van Rooyen maintained a list with names and contact details of local landowners, which atlasers used to alert landowners when they atlased in the area, or to ask permission to atlas on private land. During national lockdowns resulting from the COVID-19 pandemic in 2020, van Rooyen introduced a “lockdown challenge,” encouraging atlasers to keep lists of the birds in their gardens and submit photographs to another CS initiative, the Virtual Museum. Several interviewees emphasised the role of van Rooyen's enthusiasm and knowledge in maintaining their own interest in the project:

“My motivation...that was Johan van Rooyen, without a doubt. He's not only [an] enthusiastic person, but he's got the knowledge, also. He's an absolutely wonderful coordinator as well.”

“Johan has maps; they put exactly where you should go, and we know from ‘there’ to ‘there’ is about so many kilometres...with our project, the huge input from Johan van Rooyen—I think he keeps us going.”

“We really appreciate him. Over the lockdown, it was really difficult to still keep going, and he had ideas. We couldn’t move out of our house[s], [but] we were still able to get most of the birds that you see from your house. So we did that!”

Bonney et al. (2009a) specified three categories for public participation in scientific research: contributory, collaborative, and co-created. Though SABAP2 was designed as a contributory initiative, the community-led atlas in Hessequa marks a shift towards collaborative or community-based participation (Danielsen et al. 2014; Kennett et al. 2015; Chandler et al. 2017), with community members contributing to data collection, analysis, and project design. The role of local leadership in Hessequa’s atlas success raises questions around the sustainability of purely contributory biological CS initiatives. For the institutions driving such initiatives, our observations in Hessequa suggest that it may be worthwhile to invest in training CS leaders to coordinate fieldwork efforts in specific geographic regions, equipping local enthusiasts with skills in project management and interpersonal communication. While this coordination arose independently in Hessequa, this will almost certainly not be the case in every community. Investing in training CS leaders may positively influence project longevity.

Although it is often contended that CS requires adaptive management in order to balance the continuous fluctuation in volunteer participation and effort, we offer that this is perhaps only characteristic of CS viewed solely as a tool for data collection (Eitzel et al. 2017; Phillips et al. 2019). In Hessequa, we observed a community of citizen science participants self-organising and initiating collaboration with scientists in order to set and reach self-identified targets. This observation illuminates the possibility of CS as not only a form of resource management, but also as a tool for social transformation (Sullivan et al. 2014; Jørgensen & Jørgensen 2021). Though the project significantly increased the demands of participation on time and travel costs, Hessequa atlasers were not offered monetary compensation—participation remained voluntary with no consequences for dropping out. This seems an unlikely result; as Fraisl et al. (2022) highlight, projects that demand a great deal of time may not be ideally suited for CS data collection. What, then, might motivate the consistent contributions of Hessequa atlasers? Conversations with participants highlight critical differences between external (incentivised) and internal (personal) motivation: atlasers continued to participate in demanding and perhaps costly ways because participation held personal or relational meaning (Everett & Geoghegan 2016; Richter et al. 2018).

Atlasers described the significance of making a meaningful contribution to science in motivating their participation, shared their enjoyment of giving purpose to their hobby (birdwatching or twitching), and expressed the importance of seeing their data in use:

“I’ve been a birder for a long time...when we got involved with the SABAP programme through Johan, it gave a totally different connection to our hobby of birdwatching. All of a sudden, my hobby is purposeful. It’s not just for my pleasure; I’m doing it with something bigger in mind.”

Such statements are consistent with findings from Hidalgo et al. (2021) and Adler et al. (2020) who conclude that CS initiatives are more likely to succeed when participants are involved as coresearchers rather than data collectors. Furthermore, a sense of meaningful contribution may play a critical role in generating social change.

Meaningful contribution has been linked to increased likelihood of personal intention to engage in conservation behaviour (Day et al. 2022). In Hessequa, participants expressed that their experiences of meaningful contribution were largely enabled by the clear and continuous feedback streams maintained between scientists, local leadership, and atlasers; these statements align with responses in recent studies on participant motivation (e.g., Richter et al. 2018; Kuehn et al. 2022).

Finally, the success of the Hessequa monitoring project may be partially attributed to its community focus. Participants meet in person at regular intervals to connect with one another and discuss and divide fieldwork responsibilities. Many are also part of local group messaging streams or email lists, which members use to discuss species identification and share noteworthy observations throughout the year. In interviews, several participants described the interpersonal connections experienced through atlasing as motivations for participation. These connections were diverse, including a sense of community found with like-minded individuals, enjoying quality time with a spouse or friend while atlasing together, and a sense of communal learning through birding as part of a group. These responses are supported by Kaplan Mintz, et al. (2023), who found that for 89 citizen science participants, the primary motivation for participation was learning through social interactions.

The significance of community in this context extends beyond benefit into the realm of values—a collective that is gaining increased recognition in socioecological research for its importance in leveraging long-term behavioural change (e.g., Mattijssen et al. 2020). Even contemporary CS initiatives seldom consider the social significance of project participation beyond personal motivations. Our conversations with atlasers suggest that the social community created through project involvement is not only a strong motivator for participation, but also generates awareness and conversation surrounding local conservation issues, which may ultimately spill over into the wider community. This is reflected in the findings of Day et al. (2022), who offer that both social engagement and a sense of meaningful contribution are necessary components of social change for citizen science participants. In light of the potential broader social impact of citizen science participants as a community, it may be worthwhile for CS project managers to consider ways to connect local citizen science participants with one another and to create opportunities for meaningful interpersonal interactions between participants.

Together, the leadership, communication, and community in Hessequa create a strong foundation for project longevity and continued participant motivation. In the future, we suggest this foundation may be adapted as a model for jointly pursuing sustainable CS fieldwork and maximising conservation and social impact. The framework is flexible for adaptation in diverse contexts; leadership and communication style may be tailored to fit local needs. Additionally, we recommend that CS project leaders consider taking inventory not only of participant motivations, but also values; i.e., asking what lies beneath motivations. Understanding the deep-seated personal decision-making systems driving participant behaviour may prove valuable in structuring projects to maximise their social impact.

5. Conclusion

Mitigating biodiversity loss requires a nuanced understanding of species populations and trends at a regional level. As CS initiatives offer potential solutions to data collection challenges, it becomes necessary to both verify the

quality of data collected and ensure that collection protocol remains sustainable. Temporal proximity provides a useful measure for determining the monitoring value of semi-structured CS data to applied conservation, and systematic data collection effort (such as that employed in Hessequa) supports sustainable fieldwork objectives. In the case of Hessequa, project success is also heavily influenced by local leadership, communication, and the community of citizen science participants. Approaching CS as a tool for informing meaningful action involves consideration of not only its scientific impact, but also its social impact. This study seeks to embrace the twofold implications of a CS initiative in South Africa, and we hope that the questions raised here will enable further research in a similar vein moving forward.

Data accessibility statement

The checklist data used in our analyses were downloaded from the SABAP2 website. SABAP2 data are freely available upon request from the project team.

Ethics and consent

The interviews quoted in the discussion section of this paper were conducted with the approval of the University of Cape Town Faculty of Science Research Ethics Committee, approval code FSREC 049 – 2021. All interviewees provided informed consent to participate.

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Table 1. Note no official coordination or systematic data collection strategies were used in the Northern Swartland, Garden Route, or Western Overberg regions.

Atlasing regions and fieldwork strategies		
Region	Pentads	Fieldwork strategy
Hessequa	75	Systematic atlasing, community and scientific leadership
Greater Gauteng (GG1–8)	72	Sporadic atlasing challenges, scientific leadership
Northern Swartland	77	No coordinated atlasing
Garden Route	99	No coordinated atlasing
Western Overberg	79	No coordinated atlasing

Table 2. Note units are days prior to 31 December of the year in the row (see text). Large values represent poor temporal quality.

Annual temporal quality for SABAP2 data from 2009-2021.												
Year	Hessequa	Western Overberg	Garden Route	Northern Swartland	GG1	GG2	GG3	GG4	GG5	GG6	GG7	GG8
2009	271	113	69	96	150	138	207	103	188	196	82	198
2010	375	336	96	145	124	83	120	299	132	84	160	195
2011	471	244	222	180	247	340	267	328	91	232	172	135
2012	730	253	343	310	422	376	370	302	270	301	228	317
2013	386	451	506	458	464	304	376	276	386	438	364	390
2014	359	755	557	666	609	334	388	227	324	334	275	325
2015	146	591	507	743	443	372	358	175	404	404	249	394
2016	127	493	586	545	368	482	484	214	613	400	346	586
2017	139	470	645	674	646	592	652	246	623	500	380	623
2018	232	679	1003	772	928	652	753	297	692	674	365	688
2019	221	735	1208	822	774	585	666	359	441	684	349	751
2020	244	847	1264	455	827	502	680	334	663	729	500	760
2021	228	967	368	697	852	476	741	442	824	765	557	950

Table 3. Note units are days prior to 31 December of the year in the row (see text). Large values represent poor temporal quality.

Spring temporal quality for SABAP2 data from 2009-2021.												
Year	Hessequa	Western Overberg	Garden Route	Northern Swartland	GG1	GG2	GG3	GG4	GG5	GG6	GG7	GG8
2009	111	73	61	79	85	94	89	82	82	89	58	110
2010	468	409	68	397	75	85	75	405	69	68	258	114
2011	467	182	411	260	399	408	427	763	91	56	400	84
2012	833	421	444	428	418	766	766	113	428	412	95	408
2013	843	455	783	465	465	413	479	408	432	480	415	764
2014	1184	802	1133	824	774	463	428	115	480	436	407	816
2015	106	1162	1168	1166	810	775	452	96	625	446	436	1146
2016	400	1206	1202	1502	833	816	766	111	769	766	722	1203
2017	233	778	1548	1135	1184	1155	784	401	812	768	836	1501
2018	409	824	1582	1199	1209	1180	841	401	840	806	820	1528
2019	407	1150	1864	1528	1544	1506	1129	451	814	781	477	1530
2020	406	1186	1537	1130	829	1132	814	444	798	820	770	1515
2021	403	1536	817	848	1153	776	1158	473	1140	825	818	1216

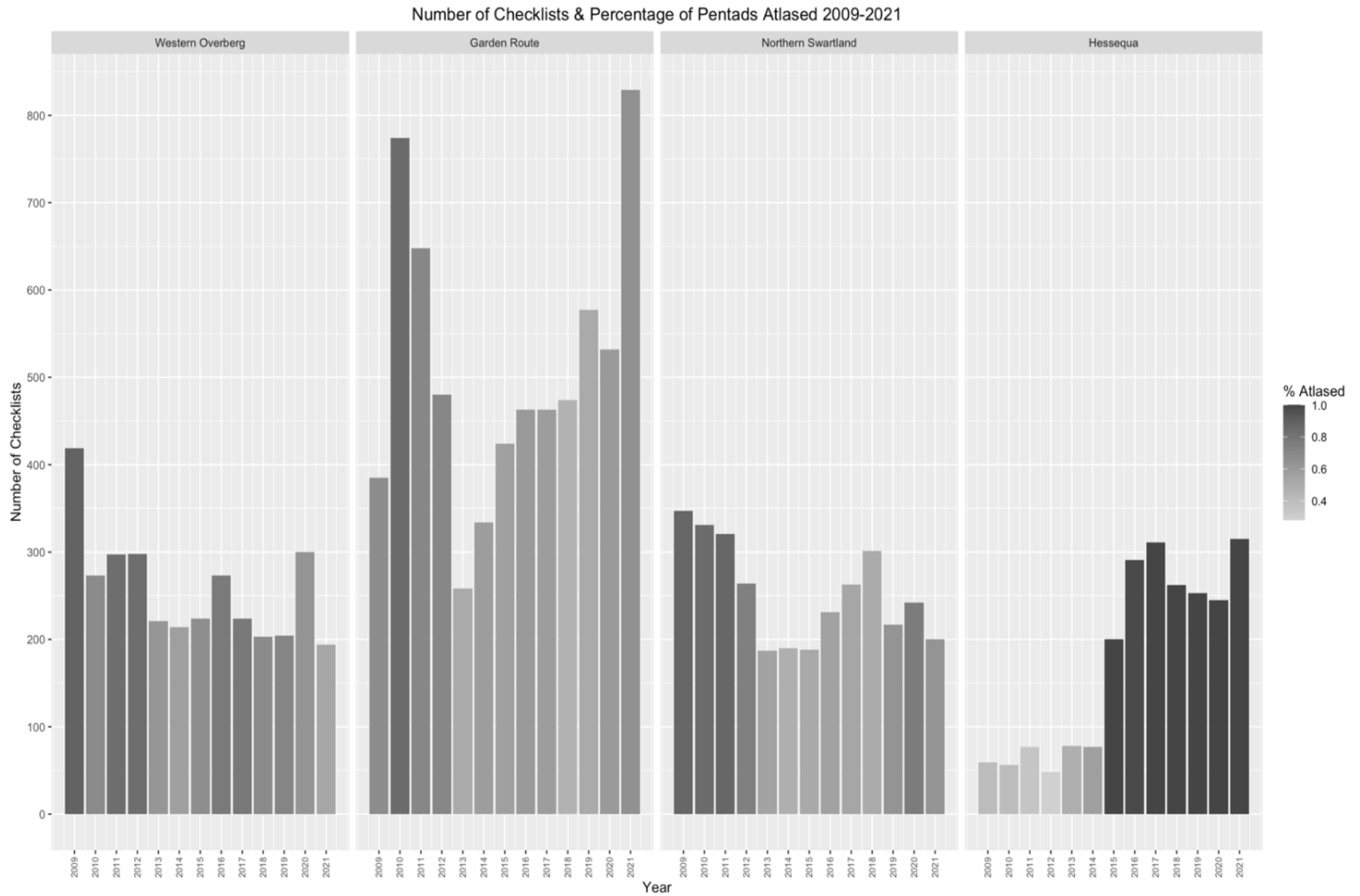


Figure 1. *Atlasing effort (number of checklists) and regional coverage (percentage of pentads atlased) in Hessequa and three Western Cape regions between 2009 and 2021. Darker colour indicates more complete coverage.*

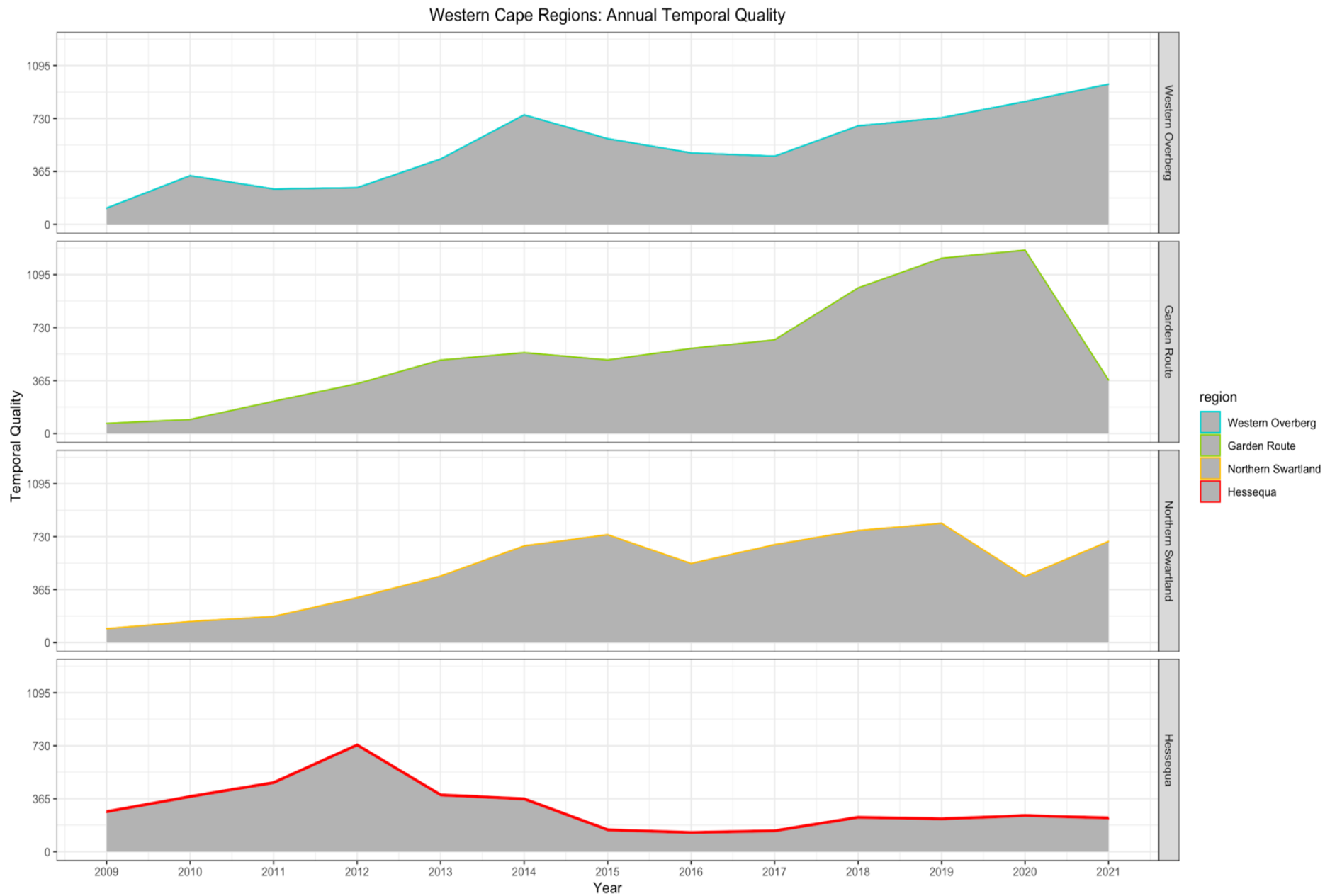


Figure 2. Temporal proximity in Hessequa and three Western Cape regions between 2009 and 2021 (see also Table 2).

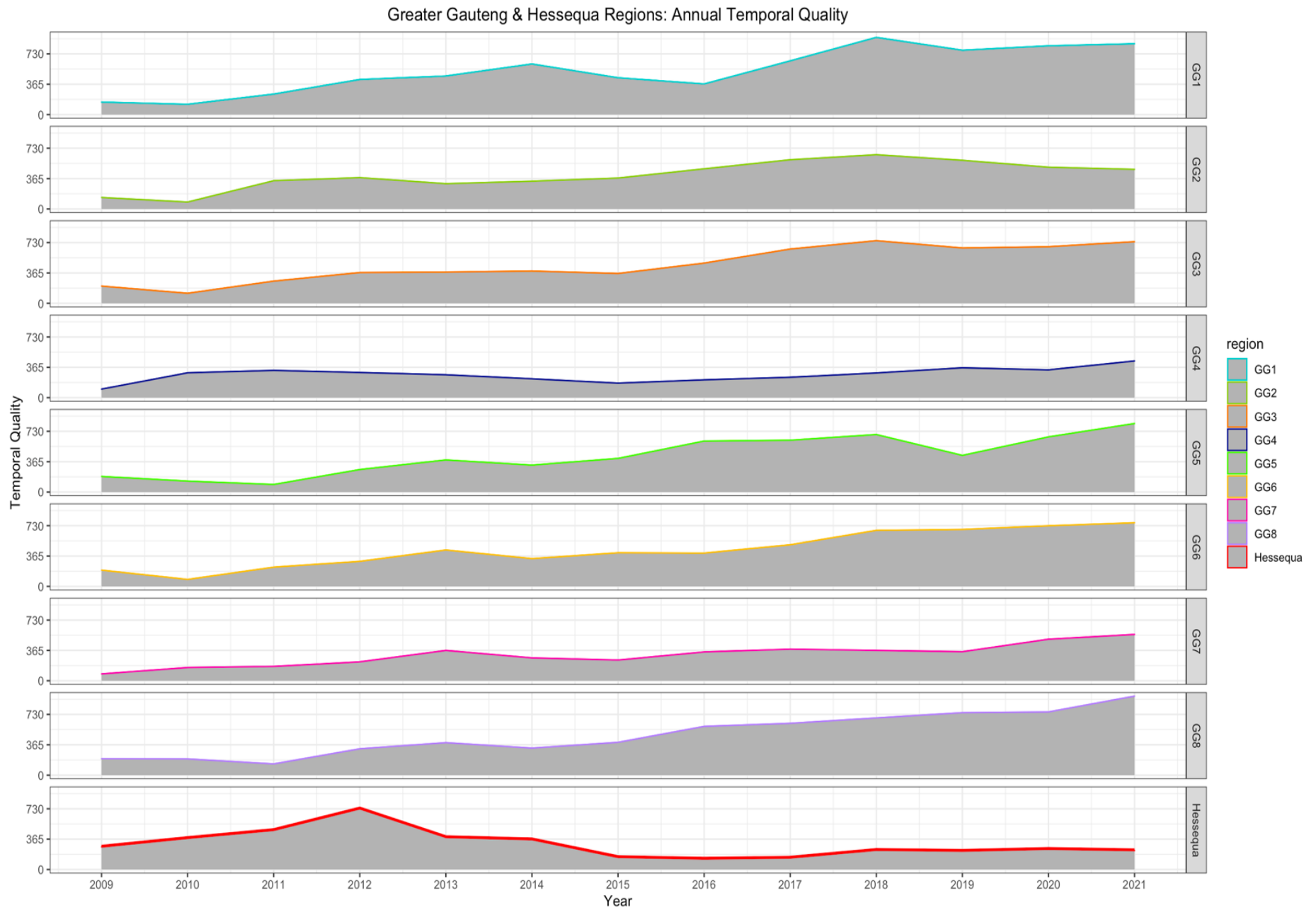


Figure 3. Temporal proximity for Hessequa and eight Greater Gauteng regions between 2009 and 2021 (see also Table 2).

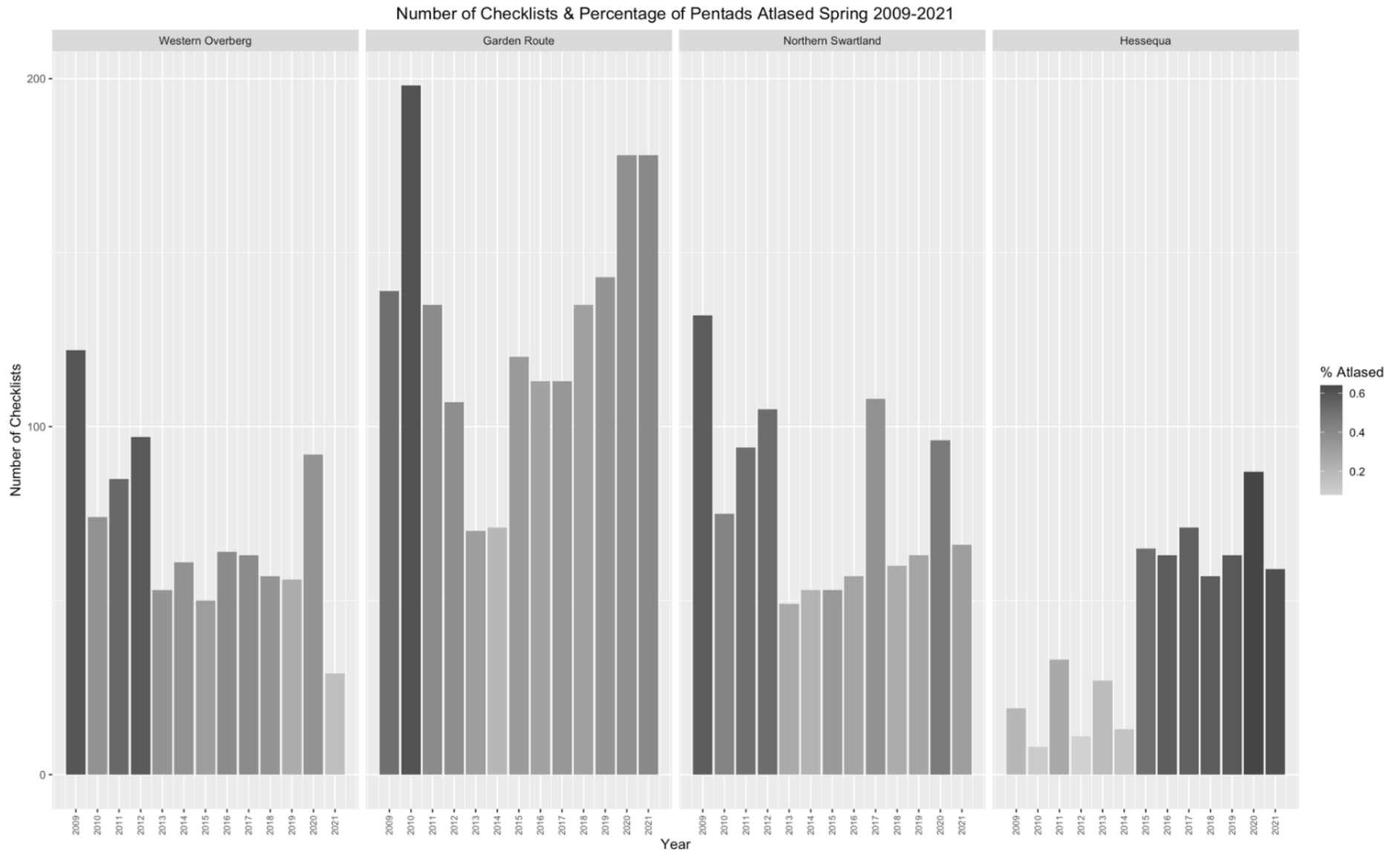


Figure 4. *Atlasing effort (number of checklists) and regional coverage (percentage of pentads atlased) in Hessequa and three Western Cape regions during the austral spring, between 2009 and 2021. Darker colour indicates more complete coverage.*

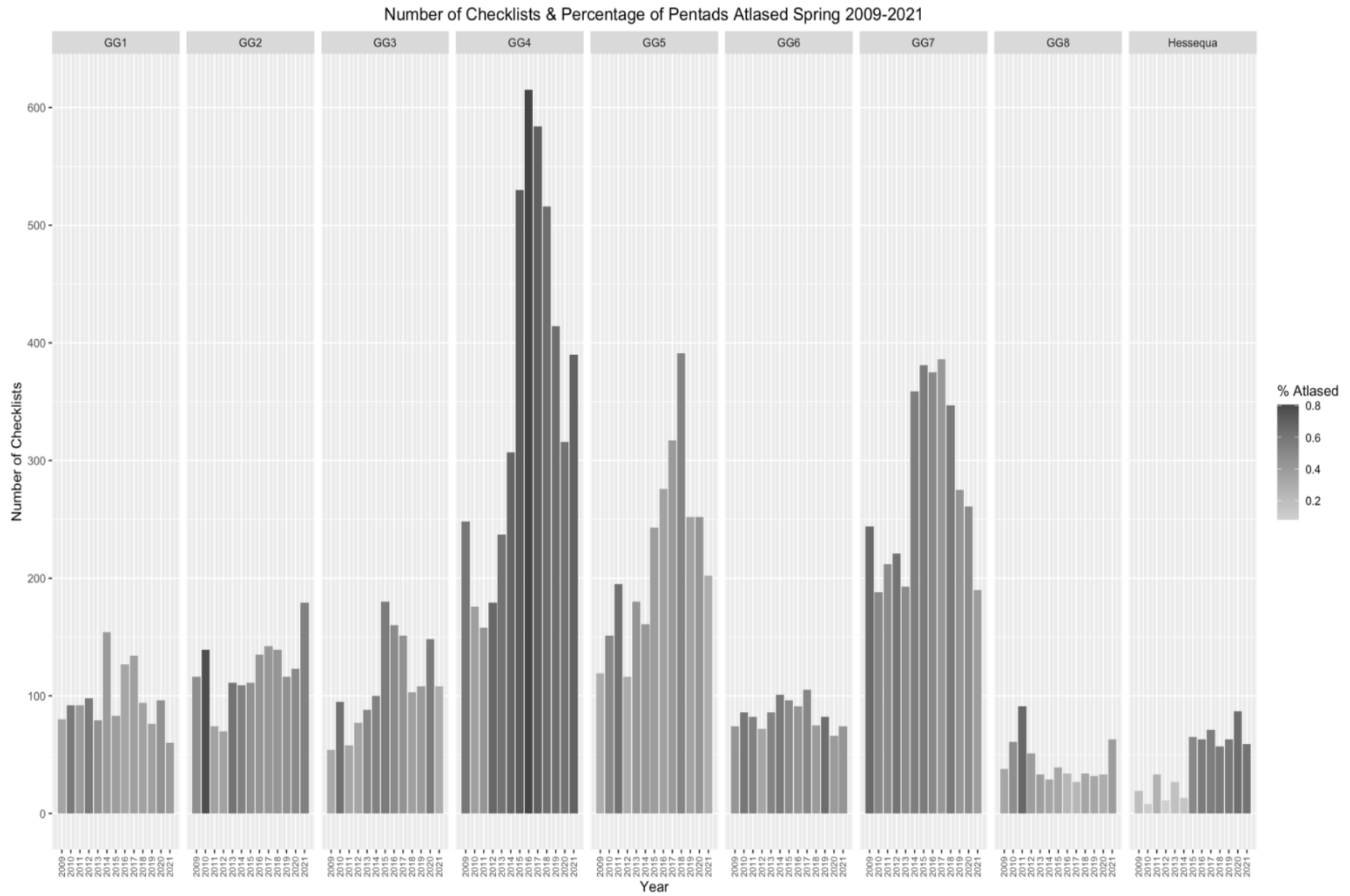


Figure 5. *Atlasing effort (number of checklists) and regional coverage (percentage of pentads atlased) in Hessequa and eight Greater Gauteng regions during the austral spring, between 2009 and 2021. Darker colour indicates more complete coverage.*

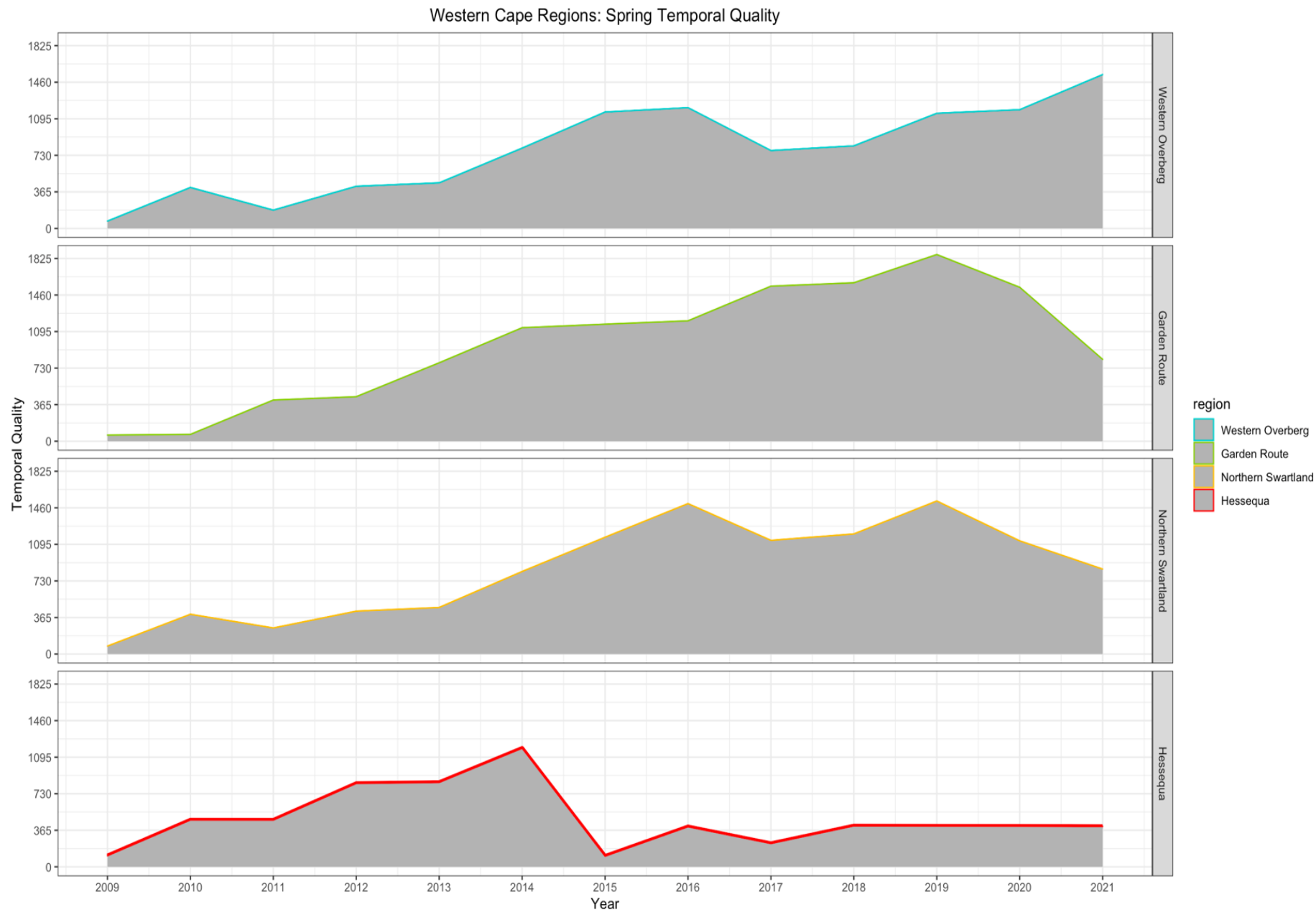


Figure 6. Temporal proximity for Hessequa and three Western Cape regions during austral spring, between 2009 and 2021 (see also Table 3).

Greater Gauteng & Hessequa Regions: Spring Temporal Quality

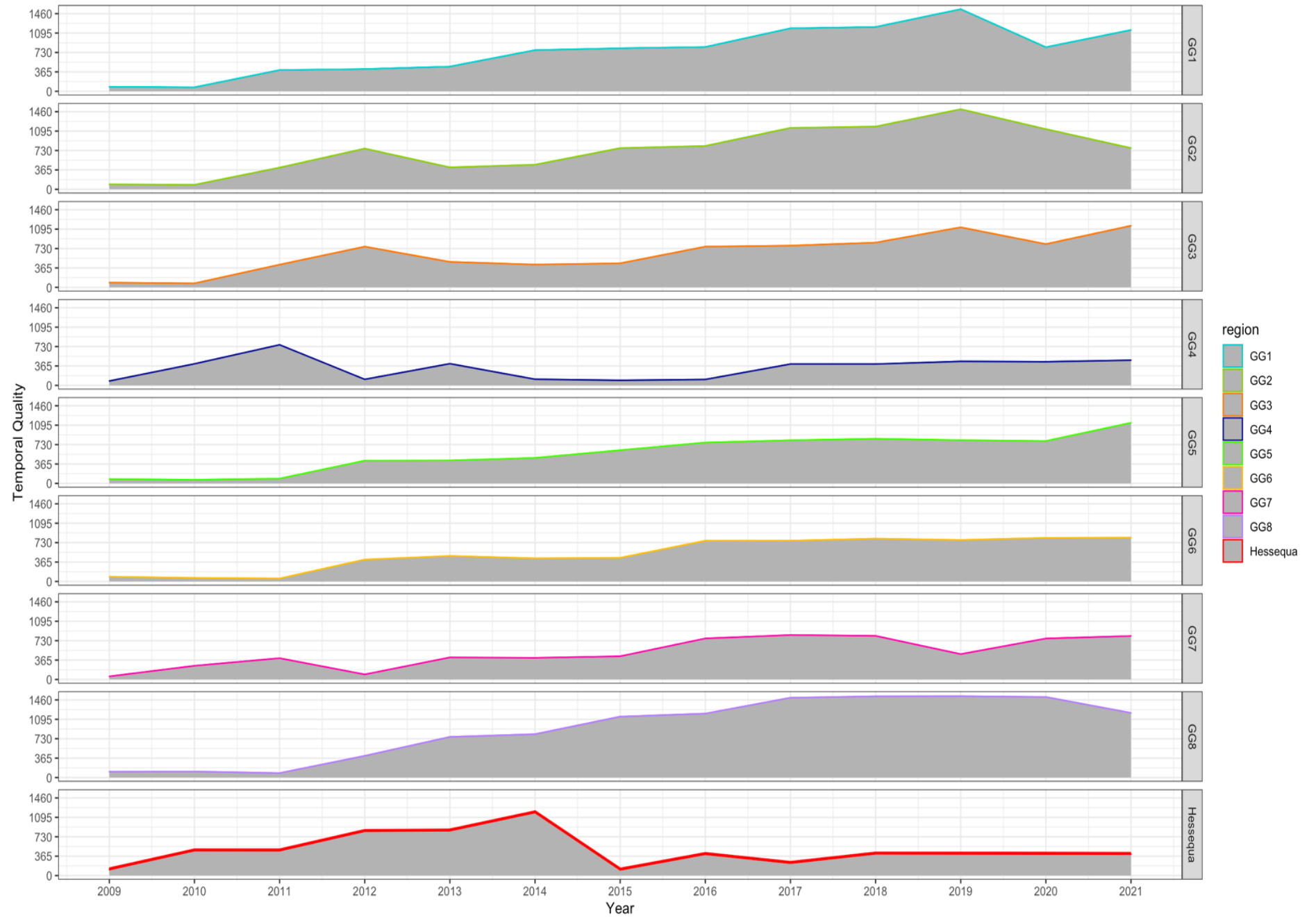


Figure 7. Temporal proximity for Hessequa and eight Greater Gauteng regions during austral spring, between 2009 and 2021 (see also Table 3).

Number of Checklists & Percentage of Pentads Atlased 2009-2021

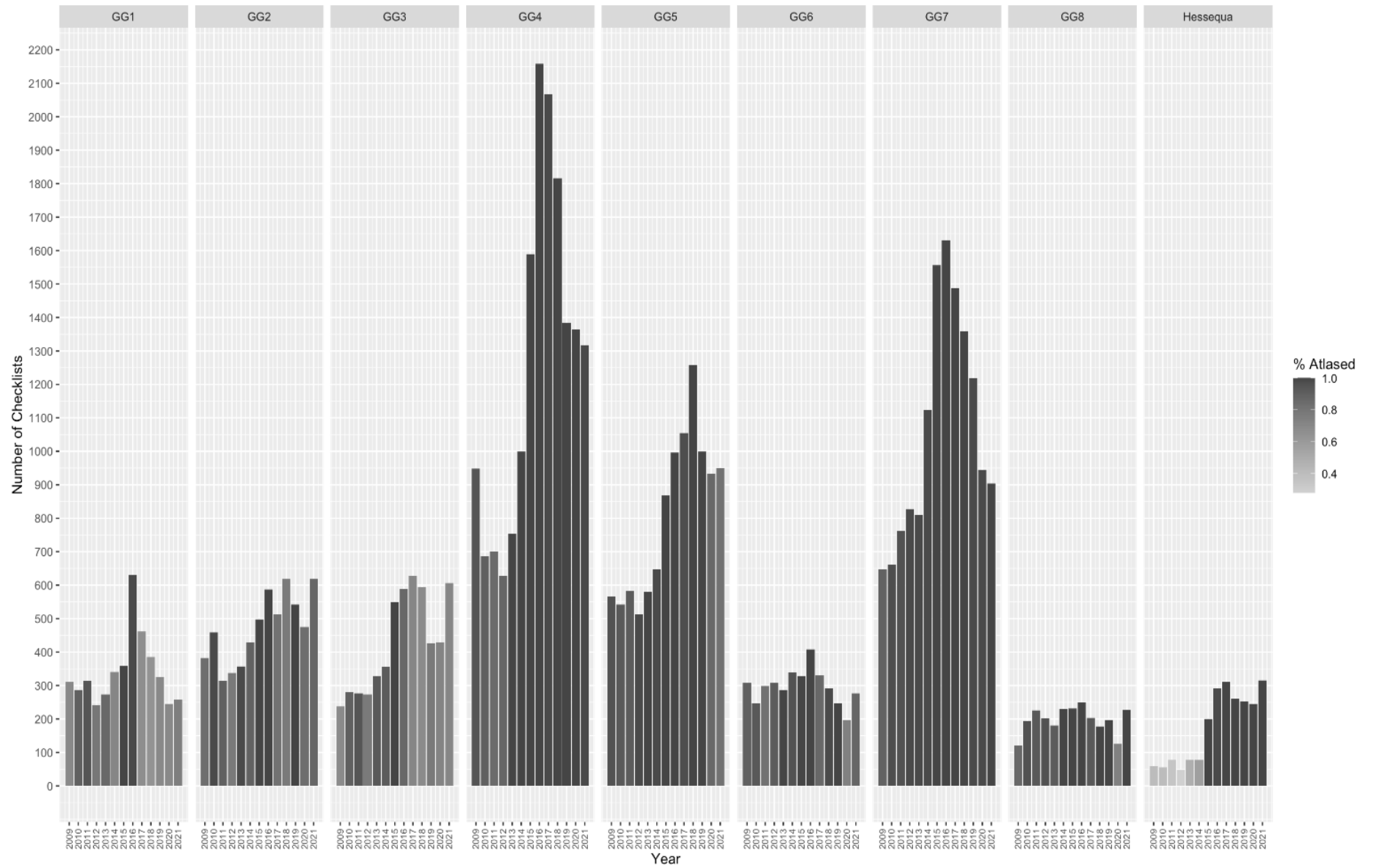


Figure 8. Atlasing effort (number of checklists) and regional coverage (percentage of pentads atlased) in Hessequa and eight Greater Gauteng regions between 2009 and 2021. Darker colour indicates more complete coverage.

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CHAPTER 4

Bird atlas in action: Using citizen science data to generate population trend alerts in Hessequa, South Africa



The greatest value of a picture is when it forces us to notice what we never expected to see.

John Tukey

Abstract

Citizen science data are rapidly transforming the conservation landscape. Targeted participatory citizen science initiatives generate nuanced data capable of monitoring trends in populations and generating early warnings for species and habitats experiencing significant declines. In the Hessequa Atlasing Area, Western Cape, South Africa, citizen science 'atlasers' involved with the Second Southern African Bird Atlas Project (SABAP2) have worked with scientific leadership since 2014 to improve the quality of bird atlas data in their region for species monitoring. In this study, we used reporting rates from SABAP2 checklists in the Hessequa Atlasing Area to calculate changes in range size and relative abundance for the 165 most commonly reported species in the region. We used a seven-tier alert system and broad habitat categories to sort species by priority for conservation action. Our results showed that wetland and marine associated species are experiencing the greatest declines in range and relative abundance in the Hessequa Atlasing Area, while urban and grassland associated species are largely increasing. We discuss how observed changes in populations may be used to guide conservation action and provide recommendations for scientists and non-scientific community members on engaging with and responding to the changes highlighted in each of the seven alert levels provided.

1. Introduction

Conservation is facing a ‘wicked’ problem (Sharman & Mlambo 2012). Biodiversity loss, the extinction of species and ecological interactions, threatens the integrity and functioning of populations and ecosystems, both human and non-human, globally (Díaz et al. 2019; Hochkirch et al. 2021; CBD 2022; Isbell et al. 2023).

Conservation scientists are asked to advise and implement strategies to mitigate losses, but are faced with data gaps and biases that impede effective action (Jetz et al. 2011; Chambers et al. 2016; Parsons 2016; Proença et al. 2017). Recent research has called for improved monitoring efforts to address data gaps, prioritise focus, and strengthen conservation measures (Proença et al. 2017; Siddig 2019); a potential solution may lie in the field of citizen science. Through collecting large quantities of species data at vast geographic scales and often from under-sampled regions, citizen science participants may contribute towards the population monitoring needed to mitigate the current biodiversity crisis.

Crucially, citizen science data may support the development of early warning systems. These systems are often constructed with the goal of disaster risk management, i.e., floods, landslides, or drought; however, in the long term, biodiversity loss may be considered a disaster of equal if not greater magnitude than any natural disaster (Barnard et al. 2017). In the context of species conservation, early warning systems may be broadly described as monitoring schema implemented with the goal of detecting significant changes among species, populations, and habitats (Jetz et al. 2019). In conservation, warning systems are already widely utilised; however, many of these are retrospective rather than prospective (Schmeller et al. (2018). For instance, the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2022) has been used internationally to raise awareness, prioritise conservation intervention, incentivise funding, and inform management and policy decisions for over 50 years (Betts et al. 2020). Although crucial, IUCN assessments occur at long intervals, and are thus likely to detect patterns late rather than early, because assessments are based on changes that have already occurred. These classifications also tend to bias interventions towards rare species and those with a high immediate extinction risk (Luther et al. 2016; Baker et al. 2018; Christie et al. 2020), potentially missing common species, species experiencing moderate to slow declines, and overlooking the importance of preventing common species from becoming rare (e.g. Dirzo et al. 2014; Ceballos et al. 2017; Weeks et al. 2022). The value of an early warning system lies in its ability to inform proactive rather than remedial conservation measures, enabling thorough evaluation and strategic response instead of rapid and reactive short-term solutions (Luther et al. 2016; Schmeller et al. 2018). Schmeller et al. (2018) identify eight biodiversity variables essential to early detection which include, among others, abundance, ecosystem heterogeneity, and range dynamics. Some recently trialled systems have focused on early detection by monitoring specific biomes, i.e. tropical rainforests (Rovero & Ahumada 2017), or implementing warning systems for low genetic diversity among indicator species in threatened habitats (Zimmerman et al. 2022), but for many taxa, particularly in the Global South, these baseline data are either scarce (Boakes et al. 2010; Feeley et al. 2016; Hoveka et al. 2020; Oliver et al. 2021; von der Heyden 2022), or are collected and housed by non-local institutions in first-world nations (Cresswell 2018; Stephenson & Stengel 2020; Asase et al. 2021; de Vos 2022; Miller et al. 2023). Citizen science offers an opportunity to collect and interpret baseline data at a regional scale, and thus is gaining traction as a facilitator of localised monitoring systems in the Global South (Gossa et al. 2015; State of India’s Birds [SoIB] 2020; Asase et al. 2021; Cyvin 2022).

To date, citizen science project data have supported early warning systems for several taxa internationally, including butterflies (Stenoien et al. 2018), plants (García et al. 2021), fish (Poursanidis & Zenetos 2013; Giovos et al. 2019), and microalgae (Hardison et al. 2019). The involvement of citizen science participants in maintaining these systems has led to the development of a new term, the participatory early warning system (e.g. Marchezini et al. 2018), referring to ground-level engagement of community members in collecting data that ultimately contribute towards the wellbeing of their immediate surroundings. In 2005, The United Nations together with the World Conference on Disaster Reduction adopted the “Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters” as a set of strategic guidelines for detecting and mitigating the impacts of natural disasters. The framework emphasised the importance of “early warning systems that are people centred, in particular systems whose warnings are timely and understandable to those at risk (...) including guidance on how to act upon warnings” (UNISDR 2005, para. 17, ii.d.9). In addition to engaging the general public in conservation, participatory systems also support a decentralised conservation narrative by encouraging collaboration, data collection, and communication with and within local scientific communities (Asase et al. 2021).

While participatory early warning systems do carry important social significance, to be effective as warning tools, data collection must be rigorous enough to meet both scientific standards and established monitoring targets. Within southern Africa, multiple citizen science projects already contribute to conservation decision-making (Barnes 1998, 2000; Robertson et al. 2010; Barnard et al. 2017); still, the role of citizen science data in informing early warning systems in southern Africa remains largely unexplored within scientific literature (Chambers et al. 2016). Several projects hold potential to strike the necessary balance between supporting a participatory early warning system and collecting meaningful data, and perhaps the strongest candidate is the Second Southern African Bird Atlas Project (SABAP2), a long-term citizen science initiative launched in 2007. Crucially from a data science perspective, SABAP2 offers a historically robust and consistently updated dataset for analysis (Underhill et al. 2017; Lee et al. 2022).

Although the quality of citizen science data is often called into question (e.g. Bird et al. 2014; Kamp et al. 2016; Johnston et al. 2021), the SABAP2 protocol is designed to mitigate the effects of spatial and observer bias by restricting participation to skilled birders and using gamification to encourage participants to both atlas in their ‘home’ region and visit regions with poor coverage (Ainsley & Underhill 2017; Underhill et al. 2017; Brown & Williams 2019; Daniel & Underhill 2023). As noted by Johnston et al. (2021), the statistical strength of citizen science data is improved using comprehensive checklists which require participants to list every species they encounter. SABAP2 employs a strict data collection protocol in which observers work in grid cells of 5×5 minutes latitude by longitude (pentads), spending two or more hours visiting as many habitat types as possible in the pentad and compiling a complete species checklist, thus enabling scientists to infer the pseudo-absence of non-detected species. The temporal dimensions of SABAP2 data quality have also been tested; coordinated systematic atlas efforts have been demonstrated to provide nuanced and up-to-date representations of species presence (Daniel & Underhill 2023).

The quality of SABAP2 data has been substantiated, yet it remains to be seen how these data may inform conservation action at the species level. Can SABAP2 data generate meaningful early warnings for populations, and if so, how might they then facilitate intervention? Trends in SABAP2 data are readily detected via reporting rates: the proportion of checklists on which a species is recorded in a grid cell (Harrison & Underhill 1997). Although some seasonal and interannual variation of reporting rates is expected, sharp or continued increase or decline may indicate an underlying problem. Identifying potential aberrances early through monitoring allows scientists and policy makers to carefully assess the situation, taking into consideration any environmental or anthropogenic changes which may correspond with or contribute to the population change, and act accordingly.

In this study, we tested the ability of systematically collected SABAP2 data from the Hessequa Atlasing Area, South Africa, to detect significant trends in populations of 165 locally common avian species. Using changes in range and relative abundance calculated from reporting rates, we sorted species into seven alert categories for early warnings, and searched for patterns between alert categories and species habitat preferences. We discuss the broader significance of the patterns we detected, including how warnings for these species may be utilised to trigger effective response. Finally, we discuss the broader social impacts of implementing a participatory warning system, and provide recommendations for employing citizen science projects as conservation tools for generating early warnings and enabling thoughtful social engagement.

2. Methods

Generating citizen science data for modelling often requires compromising data quality (i.e. temporal proximity, observer expertise, standardised protocol) in favour of quantity (Isaac et al. 2014; Daniel & Underhill 2023). Ensuring that species records are current, accurate, and collected systematically is more time-intensive and requires more specialised skills than opportunistic data collection (Boersch-Supan et al. 2019). SABAP2 was designed jointly by a team of biologists and statisticians to maximise both data quantity and quality, implementing a strict protocol to improve data integrity whilst operating at a geographic scale which feasibly allows for complete regional coverage by local citizen science participants (Underhill et al. 2017). We used reporting rates from SABAP2 checklists collected as part of a trialled monitoring scheme to calculate changes in the range and relative abundance of species in the Hessequa Atlasing Area, our region of interest.

Reporting rates as a monitoring tool

Detecting trends in species populations requires a tool sensitive enough to detect subtle shifts, and blunt enough to characterise large changes. For SABAP2 data, reporting rates offer a suitable starting point. The reporting rate for a species is defined as the proportion of checklists on which it has been recorded; the concept dates back to Linsdale (1928), who intuited that reporting rate would provide an index of abundance. Following Linsdale's work, the next important quantitative development was made by Temple & Temple (1984, 1986), who showed that where both count data and reporting rates were available, these two measures were closely correlated using Spearman's rank correlation coefficient. The use of this measure of correlation demonstrates an understanding of the reality that reporting rates are monotonically related to abundance, and the relationship is not linear

(Underhill et al. 1992). This concept was further advanced by Griffioen (2001), who recognised that mathematical ecology developed by Nachman (1981) could be applied to the relationship between abundance, denoted by N , and reporting rate R . Using data originating in the Australian Bird Count project (Ambrose 1991), he demonstrated that the relationship between the $\log(N)$ and $\log(-\log(1-R))$ was linear. The theoretical implications of Griffioen's (2001) results are explored in Underhill (submitted).

Although straightforward, the use of reporting rates to measure population trends is not without risk. Potential biases inherent within the data invariably challenge the validity of results. SABAP2 was preceded by another atlas project, SABAP1, with a more relaxed protocol and coarser spatial and temporal resolutions (Underhill et al. 1992; Harrison et al. 1997). While reporting rates from SABAP1 did generally reflect estimates of actual abundance, inconsistencies in sampling effort were an accompanying caveat to utilising the data in this way (Robertson et al. 1995). The problem of observer effort remains a contemporary concern in any atlas data analysis (e.g. Szabo et al. 2010, 2012; Huntley et al. 2012), along with seasonal and behavioural variations in the conspicuousness of a species and potential misidentifications by observers (Harrison & Underhill 1997).

Robertson et al. (2010) list seven qualities which should ideally characterise a data-strong atlas project: A spatial scale appropriate to the study taxon; the highest possible spatial and temporal resolution; the highest possible taxonomic resolution (e.g. species level identifications rather than family level); the highest possible demographic resolution (e.g. inclusive of life stage and age information); a standardised protocol with a reliable indication of sampling effort; a well-described sampling protocol; and the greatest possible number of unique sampling units (e.g. pentads). Several of these components were already included in SABAP1, and either carried over or were introduced into SABAP2. The spatial resolution of the project was increased from quarter-degree units of 15×15 minutes latitude by longitude to the pentad (5×5 minutes latitude by longitude), and the temporal resolution increased from a monthly to a five-day interval. By introducing a minimum 2-hour atlas protocol, SABAP2 reduced the uncertainty surrounding sampling effort. To minimise the chances of missing inconspicuous or seasonally gregarious species, a dimension of thoroughness was added to the sampling protocol by requiring 'atlasers' to visit as many habitat types as possible within each pentad. Finally, to address the problem of misidentification, new SABAP2 checklists are vetted automatically against existing records for the region, and panels of regional identification experts are tasked with reviewing incoming checklists and querying unusual records (Brooks et al. 2022). While the precautions built into SABAP2 certainly do not eliminate bias, they are designed to minimise its presence in checklists; thus, SABAP2 reporting rates can be considered a reasonably robust metric for monitoring avian population trends (e.g. Lee et al. 2017).

The Hessequa Atlas Area and monitoring effort

Although SABAP2 data quality is strong overall, its weakness is temporal quality. Data are not collected at the regular intervals necessary for biodiversity monitoring. This is true of many large-scale citizen science initiatives (e.g. Kelling et al. 2015); checklists remain opportunistic, meaning there is no guarantee that a pentad will be atlased with any regularity. This challenges the utility of SABAP2 as a monitoring tool, since old checklists for a pentad may not provide accurate representations of the species currently within the pentad, and inconsistent sampling diminishes the ability to detect reliable population trends for individual species (Daniel &

Underhill 2023). In 2014, citizen science participants in the Hessequa Atlasing Area, a region within the Western Cape, South Africa, collaborated with leading scientists to implement a seasonal data collection strategy, ongoing as of January 2023 (van Rooyen 2018, van Rooyen & Underhill 2020). Collection efforts were designed with the intention of generating data of sufficient temporal quality for use in monitoring; three complete monitoring cycles (2014–2017, 2018–2019 and 2020–2021) were available for detecting trends in regional populations at the time of this study.

The Hessequa Atlasing Area (Hessequa) is a region comprising 75 pentads within the Western Cape, South Africa. The region lies in the Hessequa Municipality and is bordered to the north and south respectively by the Langeberg Mountains and the sea. Although Hessequa contains some patches of natural vegetation, particularly in the mountains and along the coast, most of the region is agriculturally transformed with land used for both livestock farming (cattle and sheep) and crop production (barley, canola and wheat) (van Rooyen & Underhill 2020).

In 2014, atlasers in Hessequa joined forces with scientific leadership at the University of Cape Town to launch a regional-scale monitoring project (see Chapter 3). From 2014 until December 2017, each pentad in Hessequa was atlased at least once per year, and twice per year in 2016 and 2017. From 2017 onwards, the project ran in two-year cycles, dividing Hessequa into a chessboard pattern for the four austral seasons (van Rooyen 2018; van Rooyen & Underhill 2020; Daniel & Underhill 2023). Over each subsequent two-year cycle, half of the pentads in the region were visited for fieldwork in summer and winter during year one, and autumn and spring during year two. The remaining pentads received fieldwork in autumn and spring during year one, and summer and winter during year two. Thus, following a standard two-year cycle, every pentad in Hessequa was visited at least once in each season. Fieldwork was ongoing as of December 2022.

Generating rapid alerts using systematic bird atlas data

When considering how to use reporting rates in generating early warning systems, it is convenient to classify species of interest into alert categories based on one or more criteria (i.e. increasing/decreasing range, distribution, abundance) to aid in the communication of results. At the regional and national level, these categorisations also serve as valuable tools for comparison against larger international classification schema such as the IUCN Red List (2022), providing a deeper understanding of the status of species within a geographic region (e.g. Jiang et al. 2020). The criteria, however, are not hard categories; they fall along a continuum, and the boundaries for categories can be adjusted. In this study, we use seven categories (Table 1): large decrease in range (red); large decrease in relative abundance (amber); moderate decrease in relative abundance (yellow); stable relative abundance (green); moderate to large increase in relative abundance of ecologically neutral or positive species (blue); moderate to large increase in either range or relative abundance of ecologically negative species (e.g. alien species and agricultural pests) (purple); and moderate to large increase in range of ecologically neutral or positive species (pink).

Selecting species of interest and characterising changes

Because our aim was to generate practical recommendations for the Hessequa Atlasing Area, we focused on providing alerts for species for which mitigation measures could realistically be achieved in the region (i.e. common species). Thus, rare species (species with low reporting rates) are excluded from this analysis: we chose a cut-off reporting rate of 5%. This reporting rate was calculated over the Hessequa Atlasing Area as a whole for the entire study period 2014–2021. Although 5% may well represent an overly inclusive low limit, we chose to err on the side of caution and therefore anticipate that some species included in this analysis will be evaluated as “too rare” in the study area to warrant an alert, or for subsequent intervention to be meaningful.

Having selected the species of interest, we calculated the two main criteria needed to classify species into categories: Change in range, and change in relative abundance. For change in range, we calculated the numbers of pentads occupied by each species in the two time periods 2014–2017 and 2020–2021, and converted the two values into a ratio. Given the relatively short study period, we did not a priori expect many, or even any, species to display large changes in range size; rather, we included this category for the sake of completeness. Decreases in range size are widely considered positive correlates of increased extinction risk for a species (Mace et al. 2008; Gaston & Fuller 2009; Lee & Jetz 2010; Staude et al. 2019), though only one among a complex suite of species-specific contributors (Orme et al. 2006; Cardillo et al. 2008; Chichorro et al. 2019; Hernández-Yáñez 2022). A few studies have examined the relationship between range decrease and species declines among birds (e.g. Lee & Jetz 2010); however, birds constitute a challenging taxon since many species are migratory, nomadic, or semi-nomadic in response to weather events (Runge et al. 2015). While a significant and persistent change in range may indeed reflect, for instance, species decline, slight and variable changes cannot be considered reliable indicators of population trends. In these cases, a more sensitive tool such as relative abundance is often used as a complementary metric to better characterise population trends (Lawton 1993; McGill & Collins 2003; Huntley et al. 2012).

For species which showed negligible to moderate changes in range (0–29% increase or decrease), we estimated changes in relative abundance. To determine changes in relative abundance, we found the set of pentads in which each selected species had been recorded during the study period, i.e. the range of the species within the Hessequa Atlasing Area. For each of these pentads, we calculated C , the change in relative abundance, as described by Underhill (submitted)

$$C = \log(1-R_2)/\log(1-R_1) \quad ,$$

where R_1 is the reporting rate for the species in the grid cell for the first period of interest, and R_2 is the reporting rate for the second period. We calculated the value of C for each pentad in the range, and summarised the value by calculating the median. To avoid a logarithm of zero, we changed the value of reporting rates of 0 and 1 to 0.01 and 0.99 respectively (because the summary statistic is the median, this does not impact results).

Finally, we classified each of the species of interest by habitat association, adapting the broad categories described by Chittenden et al. (2018). Species were categorised based on habitat preferences as Marine,

Wetland, Thicket, Forest, Grassland, Fynbos, Urban, Montane, or Generalist. Species associated with more than one habitat were counted in all relevant habitat types; for example, Pied Kingfisher was counted as both a Wetland and a Marine species. Habitat categories were kept broad to encompass a variety of habitat sub-types. Thus, Marine included coastal habitat, Grassland included agricultural fields and Urban included suburban areas and gardens.

3. Results

A total of 1,951 checklists were submitted to the SABAP2 project for the Hessequa Atlasing Area between 2014 and 2021, containing a total of 109,273 records of species distribution. They represented a total of 323 species, of which 165 had reporting rates exceeding 5% for the time period.

Species experiencing greatest declines: Red, Amber and Yellow Alerts

Of the 165 species with reporting rates exceeding 5%, 23 species showed range declines exceeding 30%, and were thus categorised as Red Alerts (Table 2). Among these, six species showed range declines exceeding 50%, and four of these were Wetland associated.

Relative abundance (C) was calculated for the 132 species whose changes in range were moderate to negligible. 29 species showed decreases in relative abundance exceeding 30% (Table 2); these were assigned an Amber Alert. 26 species showed decreases in relative abundance between 11–29%, and were assigned a Yellow Alert.

By habitat preference, most species in the Red and Amber Alert categories were Grassland, Urban, and Wetland associated. However, these categories also contained the largest proportion of Marine (17 species) and Wetland (51) species. Of the 23 Red alert species, 14 were associated with Wetlands, five with Marine, and five with Forest habitat (Table 2, Figure 1). Wetland associated species were also the most prevalent in the Amber Alert category (15 species), closely followed by 11 Grassland species. Yellow Alert species were predominantly Grassland and Fynbos associated, followed by Wetland.

Stable and increasing species

Seventy-seven species were categorised as either Green (30 species) or Blue (47) Alert levels. The most common habitat type among both Green and Blue Alert species was Urban, followed by Grassland; for Blue Alert species, these were closely followed by Thicket and Forest (Figure 1). Three potentially ecologically negative species were categorised as Purple Alerts, with increases in relative abundance exceeding 30%. All three Purple Alert species were associated with Urban and Grassland habitats (Table 2, Figure 1). Seven ecologically neutral or positive species were categorised as Pink Alerts, with range increases exceeding 11%. Among these, five species were Grassland associated, followed by a mix of Thicket, Fynbos, and Urban associated species (Table 2, Figure 1).

4. Discussion

Species statuses in a global context

Species categorised under Red and Amber Alerts may reasonably be considered the most vulnerable, and thus most in need of rapid intervention. In particular, the declines in observed range far exceeded our initial expectations; we anticipated range decreases to be largely insignificant, and that the more sensitive relative abundance metric would be necessary to categorise trends for most species. That six species showed declines exceeding 50% was an unexpected and sobering result. Our findings uncovered two realities: First, species ranges are undergoing rapid and drastic changes at a local level in Hessequa, and second, consistent citizen science monitoring efforts are capable of detecting these changes.

Nineteen of the 23 species experiencing greatest declines in the Red Alert category were Wetland or Marine associated. This pattern carried over into the Amber category, where the relative abundance of Wetland species decreased by as much as 62%, as in the case of the Red-knobbed Coot (*F. cristata*). These declines are consistent with global predictions and parallel international studies; wetlands are diminishing worldwide (Maclean et al. 2011; Pringent et al. 2012), and despite some increases in populations of wetland birds in Europe and North America (Gaget et al. 2018; Rosenberg et al. 2019; Kamp et al. 2020; Lees et al. 2022), these localised increases are not necessarily reflected elsewhere (e.g. Maclean et al. 2011; SoIB 2020).

Species in the Yellow Alert category can be considered at-risk; these are species to watch carefully. 26 species in the Hessequa Atlas Area fell into this category, comprising 16% of the species included in the study. Species in the Yellow category were distributed evenly across habitat types, with the strongest concentrations in Grassland, Fynbos, and Wetland habitats. These concentrations were unsurprising; a growing body of research has identified Grassland birds as among the most vulnerable groups globally (Lee et al. 2017; Correll et al. 2019; Vaccaro et al. 2019; Rosenberg et al. 2019; Marques et al. 2020; Burns et al. 2021), with distinctions between species dependent on native grassland and those able to utilise transformed grassland habitats such as agricultural fields and cattle pasture. We observed the greatest declines in Grassland species which were dependent either exclusively on natural Grasslands or on a mixture of Grassland and a second non-Urban habitat such as Fynbos or Montane. Again, this result was unsurprising; habitat specialists are more broadly threatened by habitat conversion than generalists (Clavel et al. 2011; Le Viol et al. 2012; Sweeney & Jarzyna 2022). However, for those species able to utilise converted land, no single type of agricultural transformation appears to be conclusively “better” for avian diversity—factors supporting the greatest diversity of Grassland species vary significantly by context, rendering blanket recommendations inadequate (e.g. Batáry et al. 2006; Gil-Tena et al. 2015; Vaccaro et al. 2019; Sasaki et al. 2020). Thus, any conservation measures on behalf of local Grassland species must take local landscape into consideration.

Green and Blue Alert species comprised roughly 47% of the species included in our analysis. This is an encouraging statistic, suggesting that for nearly half of the most common species in Hessequa, populations are either stable or moderately increasing. Green and Blue categories offer insights into the factors supporting successful populations; for instance, Urban, Grassland (transformed), and Thicket associated species were more

prevalent in these two categories than any other, suggesting that these habitat types may be expanding, well-managed, or alternatively are suitable as secondary habitat choices for several species. However, more targeted examination is needed to determine the underlying drivers of increasing populations, and to determine whether any of these may be linked to corresponding population declines among Red, Amber, or Yellow Alert species. For instance, some Thicket species may be increasing due to the establishment of invasive Acacia thickets (Rogers & Chown 2013); such novel ecosystems invariably produce mixed conservation outcomes, highlighting the importance of monitoring at both the species and landscape level in parallel. Finally, Blue and Green Alert categories also included species classified as Near Threatened by BirdLife: Agulhas Long-billed Lark (*C. brevirostris*), Knysna Woodpecker (*C. notata*), and South Africa's national bird, the Blue Crane (*A. paradiseus*), all of which showed increases in relative abundance ranging from 16 to 30% in Hessequa. It is important to note, however, that regional increases do not necessarily imply species-wide increases; this concept is explored later in this chapter.

Three species were categorised as both ecologically negative and showing a large increase in range or relative abundance; note that “negative” does not necessarily denote “harmful;” introduced and alien invasive species were categorised as ecologically negative regardless of the magnitude of threat posed to local ecosystems. Two of the three species identified, House Sparrow (*P. domesticus*) and Common Starling (*S. vulgaris*), are non-native to South Africa. The third, Red-billed Quelea (*Q. quelea*), is a native species that has expanded its range southwards into the Western Cape (Oschadleus & Underhill 2006), and is widely considered an agricultural pest, responsible for economically significant grain crop damage (Berruti 2000; Oduntan et al. 2015).

Though introduced species are a topic of contention in ecology, the implications of expanding House Sparrow and Common Starling populations in southern Africa are little known. House Sparrows were first introduced to southern Africa in the 1900s and spread rapidly between human settlements (Msimanga 2001). Although the species is considered invasive, current knowledge of any potentially negative impacts of House Sparrows in South Africa is limited; a study in KwaZulu-Natal showed that local populations were concentrated in heavily transformed urban environments (e.g. shopping centres and industrial areas), and thus may not compete with or threaten native species (Magudu & Downs 2015). Like House Sparrows, Common Starlings were introduced; 18 birds were brought to Cape Town in 1897 by Cecil Rhodes, and within 50 years, were abundant across many parts of the Western Cape (Winterbottom & Liversidge 1954). Although they are often found in dense aggregations, some evidence indicates that populations of Common Starlings in South Africa do not necessarily persist within a region once established (Ivanova & Symes 2018); thus, like House Sparrows, they may not pose serious threat to native avian species.

As an agricultural pest species, Red-billed Quelea pose a social-ecological challenge, and we observed a range increase of 14% and an estimated increase in relative abundance of 102% in Hessequa. Although these numbers certainly seem to indicate a rapidly growing population, there are important details to note regarding the species' biology and phenology. Red-billed Queleas are nomadic and migratory across their range in response to rainfall events (Elliott 1990; Oschadleus 2000; Dallimer & Jones 2002) and require a specific suite of environmental conditions to establish breeding colonies (Cheke et al. 2007). Climate patterns in the southern Western Cape are

highly variable from year to year and are further complexified by the presence of microclimates (Ward et al. 2021). During our seven-year study period, Hessequa's erratic climate may have provided suitable quelea conditions over several consecutive years, with no guarantee of the conditions persisting. Alternatively, microclimates may create enough variation within Hessequa to support quelea populations year-round; this is not far-fetched, as Red-billed Quelea have been observed breeding in the Western Cape (Oschadleus 2015). Once again, our findings showcase the value of local monitoring. Paired with climate variables and predictive models, data like those from Hessequa could inform farmers across the Red-billed Quelea's range to understand when and where populations are most likely to arrive or persist, potentially preventing large-scale crop damage.

How can an alert categories inform action?

Population change does not occur in isolation. Shifts in range and relative abundance are inextricably linked to landscape ecology, climate, and anthropogenic activity. In general, the changes we observed followed a broad trajectory, with Wetland and Marine species experiencing the greatest declines, followed by Grassland and Fynbos species with moderate declines to moderate increases, and finally Urban, (agricultural) Grassland, Forest, and Thicket species remaining stable or showing significant increases. These habitat-level observations bring opportunities to explore the nuances in observed trends: Why did some Grassland species increase and others decrease? Are decreasing species habitat or dietary specialists, and are increasing species able to utilise multiple habitat and food types? Such questions lead to a deeper understanding of the niches which species occupy within a habitat, which in turn enhances our ability to design meaningful interventions.

Perhaps the best primary application for Red and Amber (or indeed any) species lists is as a tool for awareness; through facilitated workshops, local citizens and citizen science participants can be made aware of the species they are losing, and introduced, where relevant, to the habitats they share with birds (e.g. Senabre Hidalgo et al. 2021). Workshops can also incorporate community reflection, with interdisciplinary conservation practitioners working together to guide communities in considering their relationships to the declining species: Are people aware of these birds, where they live, and how they move through the world? What, if anything, makes them important to members of the community? Are there elements of cultural heritage or tradition linked to the species? What would be sacrificed in losing the species within the region? Such questions encourage individuals to consider their citizenship in ecosystems and more-than-human communities, paving pathways towards integrative experiences of nature.

A secondary purpose for Red and Amber Alerts is as an advisory tool for conservation scientists, providing guidance for determining which species are at greatest risk, prioritising and refining management, and structuring education and outreach. For instance, Wetland bird population trends are strongly associated with effective governance, and countries with weaker conservation governance see greater population declines (Amano et al. 2017; Gaget et al. 2018). Additionally, data deficiencies in countries with poor governance may skew understandings of actual population statuses and threats (Amano et al. 2017; Lees et al. 2022). In these contexts, local projects like the SABAP2 monitoring in Hessequa are crucial; if Wetland bird populations are known to be closely linked with conservation governance, SABAP2 data can be used to not only observe

population trends in relation to land change, but also to monitor the effectiveness of governance and interventions (e.g. Linz 2020).

Yellow Alerts are arguably the most critical for conservationists to consider: which species are beginning to decline, and where are they? Identifying these species early on allows scientists to stage preventative interventions rather than attempting to halt or reverse already significant declines. For Hessequa, since the Yellow Alert list was relatively short (26 species), it may be feasible to craft individually targeted studies, perhaps incentivising postgraduate research or community-led citizen science projects that investigate the factors influencing observed declines for a particular species. As well as bolstering current knowledge surrounding the species at risk, such projects also encourage a deeper civic awareness of local conservation challenges, and offer opportunities for local communities to form unique relationships with specific target species in their region (e.g. Kobori et al. 2016). There is evidence that meaningful connections with one element of non-human nature facilitate a broader and healthier relationship with non-human nature as a whole (Evans et al. 2005; Toomey & Domroese 2013) and may even increase species advocacy (Forrester et al. 2017). Yellow Alert species may provide an ideal starting point for local non-scientist community members to engage with the rest of the natural world.

With the rise of concepts such as Essential Biodiversity Variables and increasing understandings of the importance of species diversity in ecosystems, it is quickly apparent that monitoring data are valuable for all species and populations—rare, threatened, stable, and increasing (Pereira et al. 2013; McGeoch & Latombe 2015; Weeks et al. 2022). In this way, Green and Blue categories can still be considered ‘Alerts,’ as they provide critical baseline data for species that are doing well, but can also trigger further investigation for species potentially beginning to experience significant population increases. For instance, in our study, Blue Crane relative abundance was estimated to have increased by 16% between 2014 and 2021. This species is a national icon and is listed as Vulnerable by the IUCN RedList (2022) with a declining global population trend; thus, continued regional increases over a seven-year period are an encouraging statistic. Patterns like these for Green and Blue Alert species can inform research initiatives focussed on the factors supporting population increases, potentially enhancing conservation interventions for the species in other parts of their range.

Similarly, Purple Alerts are important for understanding the local implications of a species population increase. For potentially problematic species (i.e. Red-billed Quelea), a Purple Alert deepens existing knowledge of species movements and can open opportunities to engage with the people who are most affected by them. There is also opportunity for broader ecological learning; for instance, although further research is needed to understand the implications of House Sparrow and Common Starling expansion in South Africa, it is known that both species have experienced substantial declines across their native ranges which cover much of continental Europe and Asia (Crick et al. 2002; Freeman et al. 2007). Reasons for these declines remain unclear (De Laet & Summers-Smith 2007; Heldbjerg et al. 2016, 2019; Balmori 2021), but as native populations decline, there is much to be learned from South Africa’s invasive populations. Studies of genetic diversity, dispersal strategies, and post-invasion adaptations help to build an understanding of the factors and traits influencing invasion success (Berthouly-Salazar et al. 2013; Hanson et al. 2020; Stuart et al. 2022, Stuart et al. 2023).

Finally, for ecologically non-negative species, Pink Alerts can provide a clear indication of the habitat types expanding within a region, whilst improving understanding of the species diversity these habitats can support. As was the case in Hessequa, it is very possible that many species in this category will inhabit novel ecosystems. Mixed landscapes are a critical frontier in conservation, and Pink Alert species lists may be particularly valuable when paired with landscape change analysis and species lists from Red and Amber Alerts; taken together, the categories depict how different species respond to shared changes in habitat.

Citizen science as a monitoring tool

In every case, true data are preferable to modelled population estimates, and through their data collection efforts, citizen science participants make the notion of true data a real possibility. Although citizen science data are capable of meeting monitoring requirements, they may also be used in conjunction with existing management tools to improve understanding of population trends. For instance, when used in partnership with SABAP2 data, the alternative threat categories identified in BirdLife South Africa's 2018 publication, *The State of South Africa's Birds* (Taylor & Peacock 2018), the IUCN Red List (2022), or the classification scheme for endemic birds proposed by Lee et al. (2017) can situate regional monitoring efforts in a broader national or international context, enhancing the applied value of both datasets.

Furthermore, the ability of these categories to serve as a tool for informing both scientific and non-scientific communities makes them a valuable asset to conservation research, especially as the need for interdisciplinary collaboration, inclusivity, and community integration becomes increasingly apparent (Tallis & Lubchenco 2014; Gavin et al. 2015; Raymond et al. 2022). Besides the importance of the data themselves, it is also necessary to acknowledge the role of regional-scale monitoring efforts in shaping community-level conservation. As noted by Kobori et al. (2016), "*A future in which national experiments are launched to address specific environmental or biodiversity problems would certainly bode well for engaging the public in the problems of the day.*" Beyond collecting critical monitoring data, participatory early warning systems (alerts) encourage local awareness of environmental challenges and offer a sense of investment and ownership in regional-scale conservation (Seng 2012; Weise et al. 2019; Tabor & Holland 2020). In Hessequa, a small community of bird atlasers were able to generate data of sufficient quality to detect local declines. The success here suggests that implementing similar projects elsewhere may strengthen existing knowledges of species distributions, ranges, and abundance, but may also strengthen community support for the conservation measures taken on their behalf. Our study in Hessequa demonstrates the power of placing citizen science at the forefront of applied conservation; a well-structured and community-led initiative has the potential to inform individuals, decisions, and policy.

Caveats regarding regional change and rare species

When considering changes in species range and relative abundance, it is necessary to keep sight of a global context. A regional increase might indicate an overall increase in relative abundance across a species' entire range, but it might also equate to a regional decrease in relative abundance elsewhere. In fact, this appears to be the case for the Blue Crane; this species is relatively new in the Western Cape, where recent transformations of

Fynbos and Renosterveld to artificial grassland have supported the movement of Blue Cranes into the province (McCann et al. 2007; Young & Harrison 2020). As the concentration of Blue Cranes in the Western Cape increased, populations in eastern grassland habitats experienced sharp declines, largely driven by land transformation (McCann et al. 2007), and as of 2009, roughly half of South Africa's Blue Crane population were estimated to inhabit artificial grasslands in the Western Cape (Pettifor et al. 2009). Thus, while Blue Cranes in the Hessequa region are increasing in relative abundance, populations in other provinces are declining.

Regional changes may also reflect range changes for a species as a whole. For instance, the Knysna Warbler (*B. sylvaticus*) in our study area showed a decrease in relative abundance of 91% and is primarily associated with Thicket and Forest habitats. SABAP2 data have indicated general declines in South Africa's Forest bird species (Cooper et al. 2017), but Lee et al. (2017) found that Knysna Warbler populations were moving eastward in southern Africa. These uncertainties reiterate the importance of context surrounding an alert; local declines must be vetted against range-wide trends and species biology to understand whether the observed changes are anthropogenic or stochastic in origin (Prochazka et al. 2023). For the Knysna Warbler, several factors may be at play, as birds are likely moving eastwards in response to habitat degradation in their historic range and are also threatened by low habitat connectivity within their current range (Lee et al. 2017). Untangling the truth requires monitoring at both small and large spatial scales, and a combination of current and historic data.

Because we elected to omit rare species from our study in order to focus on the core avifaunal composition of the region, it is also necessary to consider the species we may have missed in our analyses. While most of the rare species are assumed to be vagrants to Hessequa, some of the birds omitted may well be cryptic species with low detection probabilities, or species with narrow ranges whose local populations had dwindled below our 5% reporting rate cut-off. The latter possibility is of greater concern, as it may have resulted in overlooking species perhaps most in need of rapid intervention.

5. Conclusion

The value of this research is twofold: it provides valuable insight into the state of Hessequa's avian populations, and demonstrates the potential for citizen science as a monitoring tool to generate early warnings for biodiversity loss. Using systematically collected atlas data, we were able to detect significant changes in range and relative abundance for the most commonly reported species in the Hessequa region and categorise these changes by cause for conservation concern. We found that Wetland, Marine and Grassland species in particular are experiencing severe declines and noted increases for several transformed Grassland and Urban associated species. Our alert levels can guide both conservationists and community members in understanding and engaging with the status of local species. Crucially, alert levels may be used to prioritise regional conservation interventions for particular species or habitats, and support community involvement in species conservation. These results are a testament to the value of regional-scale monitoring; in a seven-year period, citizen science participants maintained a sufficient quality and quantity of data to support robust statistical analysis with meaningful conservation applications. Participatory citizen science initiatives may benefit from structuring data collection in ways similar to the Hessequa project; our research outcomes suggest that this style of monitoring benefits the scientific community (improving knowledge of species statuses), local communities

(structuring conservation outreach and encouraging individuals to think about species in new ways), and ultimately, the species themselves (informing conservation intervention). Such collaborative and targeted initiatives may comprise the necessary future of an inclusive and interdisciplinary conservation.

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Table 1. Seven alert level categories for species populations based on changes in range and relative abundance.

<i>Alert</i>	<i>Description</i>	<i>Criteria</i>
<i>Red</i>	Large decrease in species range	Decrease of 30% or more in range
<i>Amber</i>	Large decrease in species relative abundance	Decrease of 30% or more in relative abundance
<i>Yellow</i>	Moderate decrease in species relative abundance	Decrease of 11–29% in relative abundance
<i>Green</i>	Stable species relative abundance	10% decrease–10% increase in relative abundance
<i>Blue</i>	Moderate to large increase in relative abundance of ecologically neutral or positive species	Increase of 11% or more in relative abundance
<i>Purple</i>	Moderate to large increase in either range or relative abundance of ecologically negative species	Increase of 11% or more in range or relative abundance
<i>Pink</i>	Moderate to large increase in range of ecologically neutral or positive species	Increase of 11% or more in range

Table 2. Range changes for the 165 species in the Hessequa Atlas Area with reporting rates exceeding 5%. Note the prevalence of Wetland and Marine species in the Red Alert category, Wetland and Grassland species in the Amber Alert category, Grassland, Fynbos and Wetland species in the Yellow Alert category, and Grassland and/or Urban species in the Purple and Pink Alert categories.

Alert	Species	Common name	Habitat	Range change from 2014–2021 (%)	Relative abundance change from 2014–2021 (median %)	
Red	<i>Calidris minuta</i>	Little Stint	Wetland	-70.0	--	
	<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron	Wetland	-64.7	--	
	<i>Indicator minor</i>	Lesser Honeyguide	Forest	-60.0	--	
	<i>Zapornia flavirostra</i>	Black Crake	Wetland	-59.1	--	
	<i>Tringa nebularia</i>	Common Greenshank	Wetland	-58.1	--	
	<i>Ciconia ciconia</i>	White Stork	Grassland	-54.1	--	
	<i>Muscicapa adusta</i>	African Dusky Flycatcher	Forest	-48.4	--	
	<i>Tachymarpis melba</i>	Alpine Swift	Grassland	-48.1	--	
	<i>Corythornis cristatus</i>	Malachite Kingfisher	Wetland	-47.5	--	
	<i>Phyllastrephus terrestris</i>	Terrestrial Brownbul (Bulbul)	Forest, Thicket	-45.2	--	
	<i>Charadrius hiaticula</i>	Common Ringed Plover	Marine	-41.7	--	
	<i>Morus capensis</i>	Cape Gannet	Marine	-41.7	--	
	<i>Circus maurus</i>	Black Harrier	Fynbos, Grassland	-41.5	--	
			Hamerkop	Wetland	-40.7	--
		<i>Scopus umbrette</i>				
		<i>Ceryle rudis</i>	Pied Kingfisher	Wetland, Marine	-38.5	--
		<i>Chrysococcyx caprius</i>	Dideric (Diederik) Cuckoo	Forest, Urban	-33.3	--
		<i>Centropus burchellii</i>	Burchell's Coucal	Forest, Urban, Wetland	-33.3	--
		<i>Himantopus himantopus</i>	Black-winged Stilt	Wetland	-32.4	--
		<i>Gallinula chloropus</i>	Common Moorhen	Wetland	-31.8	--
	<i>Megaceryle maxima</i>	Giant Kingfisher	Wetland, Marine	-31.3	--	
	<i>Spatula smithii</i>	Cape Shoveler	Wetland	-31.0	--	
	<i>Charadrius marginatus</i>	White-fronted Plover	Wetland, Marine	-30.8	--	
	<i>Platalea alba</i>	African Spoonbill	Wetland	-29.5	--	
Amber	<i>Bradypterus sylvaticus</i>	Knysna Warbler	Forest, Thicket	--	-91.5	
	<i>Melierax canorus</i>	Southern Pale Chanting Goshawk	Fynbos, Grassland	--	-74.9	
	<i>Apus barbatus</i>	African Black (Black) Swift	Grassland, Montane	--	-63.5	
	<i>Fulica cristata</i>	Red-knobbed Coot	Wetland	--	-61.8	
	<i>Caprimulgus pectoralis</i>	Fiery-necked Nightjar	Thicket, Urban	--	-60.6	
	<i>Anas capensis</i>	Cape Teal	Wetland	--	-60.3	

	<i>Acrocephalus gracilirostris</i>	Lesser Swamp- (Cape Reed) Warbler	Wetland	--	-59.1
	<i>Tachybaptus ruficollis</i>	Little Grebe (Dabchick)	Wetland	--	-52.5
	<i>Microcarbo africanus</i>	Reed (Long-tailed) Cormorant	Wetland	--	-51.2
	<i>Bubulcus ibis</i>	Cattle Egret	Grassland, Wetland	--	-50.8
	<i>Larus dominicanus</i>	Kelp Gull	Marine	--	-49.9
	<i>Psalidoprocne pristoptera</i>	Black Saw-wing	Forest	--	-49.2
	<i>Riparia paludicola</i>	Brown-throated (Plain) Martin	Wetland, Fynbos	--	-46.1
	<i>Serinus canicollis</i>	Cape (Yellow-crowned) Canary	Grassland, Fynbos, Urban	--	-45.4
	<i>Vidua macroura</i>	Pin-tailed Whydah	Grassland, Urban	--	-45
	<i>Buteo buteo</i>	Steppe (Common) Buzzard	Grassland	--	-45
	<i>Ardea cinerea</i>	Grey Heron	Wetland	--	-42.7
	<i>Charadrius tricollaris</i>	Three-banded Plover	Wetland	--	-41.5
	<i>Urocolius indicus</i>	Red-faced Mousebird	Forest, Urban	--	-39.9
	<i>Anas erythrorhyncha</i>	Red-billed Teal (Duck)	Wetland	--	-39.3
	<i>Ardea melanocephala</i>	Black-headed Heron	Grassland, Wetland	--	-38.3
	<i>Cisticola textrix</i>	Cloud (Tink-tink) Cisticola	Grassland, Fynbos	--	-36
	<i>Threskiornis aethiopicus</i>	African Sacred (Sacred) Ibis	Grassland, Wetland	--	-35.9
	<i>Anhinga rufa</i>	African Darter	Wetland	--	-35
	<i>Promperops cafer</i>	Cape Sugarbird	Fynbos	--	-34.5
	<i>Accipiter tachiro</i>	African Goshawk (incl. Red-chested)	Forest, Urban	--	-34.3
	<i>Elanus caeruleus</i>	Black-shouldered (winged) Kite	Grassland, Fynbos	--	-32.9
	<i>Estrilda astrild</i>	Common Waxbill	Grassland, Wetland	--	-32.2
	<i>Phalacrocorax lucidus</i>	White-breasted (Great) Cormorant	Wetland, Marine	--	-31.7
Yellow	<i>Zosterops virens</i>	Cape White-eye	Forest, Urban	--	-29
	<i>Sphenoeacus afer</i>	Cape Grassbird	Grassland, Fynbos	--	-29
	<i>Corvus albicollis</i>	White-necked Raven	Grassland, Fynbos, Montane	--	-28
	<i>Crithraga sulphurata</i>	Brimstone (Bully) Canary	Forest, Fynbos, Urban	--	-28
	<i>Nectarinia famosa</i>	Malachite Sunbird	Grassland, Fynbos, Urban	--	-26
	<i>Buteo rufofuscus</i>	Jackal Buzzard	Fynbos, Grassland, Montane	--	-26

	<i>Plectropterus gambensis</i>	Spur-winged Goose	Grassland, Wetland	--	-24
	<i>Hydroprogne caspia</i>	Caspian Tern	Wetland, Marine	--	-24
	<i>Cisticola juncidis</i>	Zitting (Fan-tailed) Cisticola	Grassland, Wetland	--	-23
	<i>Halcyon albiventris</i>	Brown-hooded Kingfisher	Forest, Urban	--	-22
	<i>Onychognathus morio</i>	Red-winged Starling	Fynbos, Urban, Montane	--	-22
	<i>Cisticola tinniens</i>	Le Vaillant's (Tinkling) Cisticola	Wetland	--	-22
	<i>Eupodotis vigorsii</i>	Karoo Korhaan	Grassland	--	-20
	<i>Falco rupicolus</i>	Rock Kestrel	Montane, Grassland, Fynbos, Urban	--	-20
	<i>Neotis denhami</i>	Denham's (Stanley's) Bustard	Grassland, Fynbos	--	-19
	<i>Anas undulata</i>	Yellow-billed Duck	Wetland	--	-18
	<i>Hirundo rustica</i>	Barn (European) Swallow	Generalist	--	-17
	<i>Cercotrichas coryphoeus</i>	Karoo Scrub-Robin	Fynbos, Urban	--	-16
	<i>Pluvialis squatarola</i>	Grey (Black-bellied) Plover	Wetland, Marine	--	-15
	<i>Apus caffer</i>	White-rumped Swift	Generalist	--	-15
	<i>Hirundo albigularis</i>	White-throated Swallow	Grassland, Wetland, Fynbos	--	-15
	<i>Euplectes capensis</i>	Yellow (Yellow-rumped) Bishop (Widow)	Grassland, Fynbos	--	-15
	<i>Ptyonoprogne fuligula</i>	Rock Martin	Fynbos, Urban, Montane	--	-15
	<i>Cecropis cucullate</i>	Greater Striped-Swallow	Grassland, Fynbos	--	-15
	<i>Platalea alba</i>	African Spoonbill	Wetland	--	-14
	<i>Euplectes orix</i>	Southern Red (Red) Bishop	Grassland, Wetland	--	-14
Green	<i>Laniarius ferrugineus</i>	Southern Boubou	Forest, Thicket, Fynbos, Urban	--	-5
	<i>Haliaeetus vocifer</i>	African Fish-Eagle	Wetland	--	0
	<i>Bradypterus baboecala</i>	Little Rush- (African Sedge) Warbler	Wetland	--	0
	<i>Cuculus solitarius</i>	Red-chested Cuckoo	Forest, Urban	--	0
	<i>Ploceus velatus</i>	Southern Masked-Weaver	Grassland, Wetland, Urban	--	0
	<i>Dendrocygna viduata</i>	White-faced (Whistling-) Duck	Wetland	--	0
	<i>Saxicola torquatus</i>	African (Common) Stonechat	Grassland	--	0
	<i>Andropadus importunes</i>	Sombre Greenbul (Bulbul)	Forest, Thicket	--	0
	<i>Cisticola subruficapilla</i>	Grey-backed (Red-headed) Cisticola	Fynbos	--	0

	<i>Vanellus armatus</i>	Blacksmith Lapwing (Plover)	Grassland, Wetland	--	0
	<i>Lamprotornis bicolor</i>	Pied (African Pied) Starling	Grassland	--	0
	<i>Bostrychia hagedash</i>	Hadedda Ibis	Grassland, Urban	--	0
	<i>Streptopelia semitorquata</i>	Red-eyed Dove	Forest, Urban	--	0
	<i>Streptopelia capicola</i>	Cape Turtle (Ring-necked) Dove	Forest, Urban	--	0
	<i>Lanius collaris</i>	Common Fiscal	Grassland, Urban	--	0
	<i>Telophorus zeylonus</i>	Bokmakierie	Fynbos, Thicket, Grassland, Urban	--	0
	<i>Upupa Africana</i>	African Hoopoe	Grassland, Urban	--	0
	<i>Crithagra gularis</i>	Streaky-headed Seedeater (Canary)	Grassland, Thicket, Forest, Urban	--	0
	<i>Charadrius pecuarius</i>	Kittlitz's Plover	Wetland, Marine, Grassland	--	0
	<i>Numida meleagris</i>	Helmeted Guineafowl	Generalist	--	3
	<i>Haematopus moquini</i>	African Black Oystercatcher	Marine	--	3
	<i>Terpsiphone viridis</i>	African Paradise-Flycatcher	Forest, Thicket, Urban	--	6
	<i>Passer diffuses</i>	Southern Grey-headed Sparrow (split)	Grassland, Urban	--	6
	<i>Colius striatus</i>	Speckled Mousebird	Forest, Thicket, Urban	--	8
	<i>Apalis thoracica</i>	Bar-throated Apalis	Forest, Thicket, Urban	--	9
	<i>Emberiza capensis</i>	Cape Bunting	Montane, Grassland, Thicket, Urban	--	9
	<i>Crithagra albogularis</i>	White-throated Canary	Montane, Thicket, Urban	--	9
	<i>Hirundo dimidiata</i>	Pearl-breasted Swallow	Grassland, Wetland, Fynbos	--	9
	<i>Tricholaema leucomelas</i>	Acacia Pied (Pied) Barbet	Fynbos, Thicket, Grassland, Urban	--	10
	<i>Crithagra flaviventris</i>	Yellow Canary	Grassland, Urban	--	10
Blue	<i>Dicrurus adsimilis</i>	Fork-tailed Drongo	Forest, Thicket, Urban	--	11

<i>Cossypha caffra</i>	Cape Robin-Chat	Forest, Thicket, Urban	--	11
<i>Macronyx capensis</i>	Cape (Orange-throated) Longclaw	Grassland, Fynbos	--	11
<i>Sterna hirundo</i>	Common Tern	Marine	--	12
<i>Turdus olivaceus</i>	Olive Thrush (split)	Forest, Urban	--	12
<i>Tadorna cana</i>	South African Shelduck	Wetland	--	13
<i>Columba guinea</i>	Speckled (Rock) Pigeon	Montane, Grassland, Urban	--	13
<i>Cisticola fulvicapilla</i>	Neddicky (Piping Cisticola)	Grassland, Fynbos	--	13
<i>Apus affinis</i>	Little Swift	Generalist	--	13
<i>Chrysococcyx klaas</i>	Klaas's Cuckoo	Forest, Urban	--	14
<i>Melaenornis silens</i>	Fiscal Flycatcher	Thicket, Urban	--	14
<i>Motacilla capensis</i>	Cape Wagtail	Wetland, Urban	--	14
<i>Burhinus vermiculatus</i>	Water Thick-knee (Dikkop)	Wetland	--	15
<i>Bubo africanus</i>	Spotted Eagle-Owl	Grassland, Forest, Urban	--	15
<i>Vanellus coronatus</i>	Crowned Lapwing (Plover)	Grassland	--	16
<i>Grus paradisea</i>	Blue Crane	Grassland	--	16
<i>Prinia maculosa</i>	Karoo Prinia (split)	Fynbos, Thicket, Urban	--	17
<i>Certhilauda brevirostris</i>	Agulhas Long-billed Lark (split)	Grassland	--	17
<i>Chalcomitra amethystine</i>	Amethyst (Black) Sunbird	Forest, Urban	--	18
<i>Tchagra tchagra</i>	Southern Tchagra	Fynbos, Thicket, Forest	--	21
<i>Burhinus capensis</i>	Spotted Thick-knee (Dikkop)	Grassland, Urban, Marine	--	22
<i>Cinnyris afer</i>	Greater Double-collared Sunbird	Forest, Thicket, Fynbos, Urban	--	26
<i>Cinnyris chalybeus</i>	Southern Double-collared Sunbird	Forest, Thicket, Fynbos, Urban	--	30
<i>Batis capensis</i>	Cape Batis	Forest, Thicket	--	30
<i>Campethera notata</i>	Knysna Woodpecker	Forest, Thicket	--	31
<i>Milvus aegyptius</i>	Yellow-billed Kite	Generalist	--	33
<i>Egretta garzetta</i>	Little Egret	Wetland, Marine	--	37
<i>Corvus albus</i>	Pied Crow	Generalist	--	37
<i>Chlorophoneus olivaceus</i>	Olive Bush-Shrike	Forest, Thicket	--	37

	<i>Numenius phaeopus</i>	Common (Whimbrel) Whimbrel	Wetland, Marine	--	38
	<i>Anthus cinnamomeus</i>	African (Grassveld, Grassland) Pipit	Grassland	--	40
	<i>Phalacrocorax capensis</i>	Cape Cormorant	Marine	--	41
	<i>Anthobaphes violacea</i>	Orange-breasted Sunbird	Fynbos	--	45
	<i>Pternistis capensis</i>	Cape Spurfowl (Francolin)	Fynbos, Grassland, Urban	--	53
	<i>Galerida magnirostris</i>	Large-billed Lark	Grassland	--	55
	<i>Oenanthe familiaris</i>	Familiar Chat	Montane, Urban	--	58
	<i>Mirafra apiata</i>	Cape Clapper Lark (split)	Grassland, Fynbos	--	58
	<i>Ploceus capensis</i>	Cape Weaver	Grassland, Fynbos, Urban, Thicket	--	80
	<i>Alophochen aegyptiaca</i>	Egyptian Goose	Grassland, Wetland, Urban	--	85
	<i>Passer melanurus</i>	Cape Sparrow	Thicket, Urban	--	85
	<i>Corvus capensis</i>	Cape (Black) Crow	Grassland	--	85
	<i>Thalasseus sandvicensis</i>	Sandwich Tern	Marine	--	99
	<i>Pycnonotus capensis</i>	Cape Bulbul	Forest, Fynbos, Urban	--	110
	<i>Oenanthe pileata</i>	Capped Wheatear	Grassland	--	185
	<i>Spilopelia senegalensis</i>	Laughing (Palm) Dove	Grassland, Thicket, Urban	--	216
	<i>Thalasseus bergii</i>	Swift (Great Crested) Tern	Marine	--	251
	<i>Dendropicos fuscescens</i>	Cardinal Woodpecker	Forest, Thicket	--	306
Purple	<i>Passer domesticus</i>	House Sparrow	Urban	--	38
	<i>Sturnus vulgaris</i>	Common (European) Starling	Grassland, Urban	--	75
	<i>Quelea quelea</i>	Red-billed Quelea	Grassland	14	102
Pink	<i>Calandrella cinerea</i>	Red-capped Lark	Grassland	13	64
	<i>Coturnix coturnix</i>	Common Quail	Grassland	13	45
	<i>Oena capensis</i>	Namaqua Dove	Grassland, Thicket	16	61
	<i>Coccyzygia melanotis</i>	Swee (Black-faced) Waxbill (Swee)	Grassland, Urban	29	22
	<i>Scleroptila afra</i>	Grey-winged Francolin	Grassland, Fynbos	41	
	<i>Sylvietta rufescens</i>	Long-billed (Cape) Crombec	Thicket	46	
	<i>Columba arquatrix</i>	African Olive- (Rameron) Pigeon	Forest, Thicket, Urban	50	

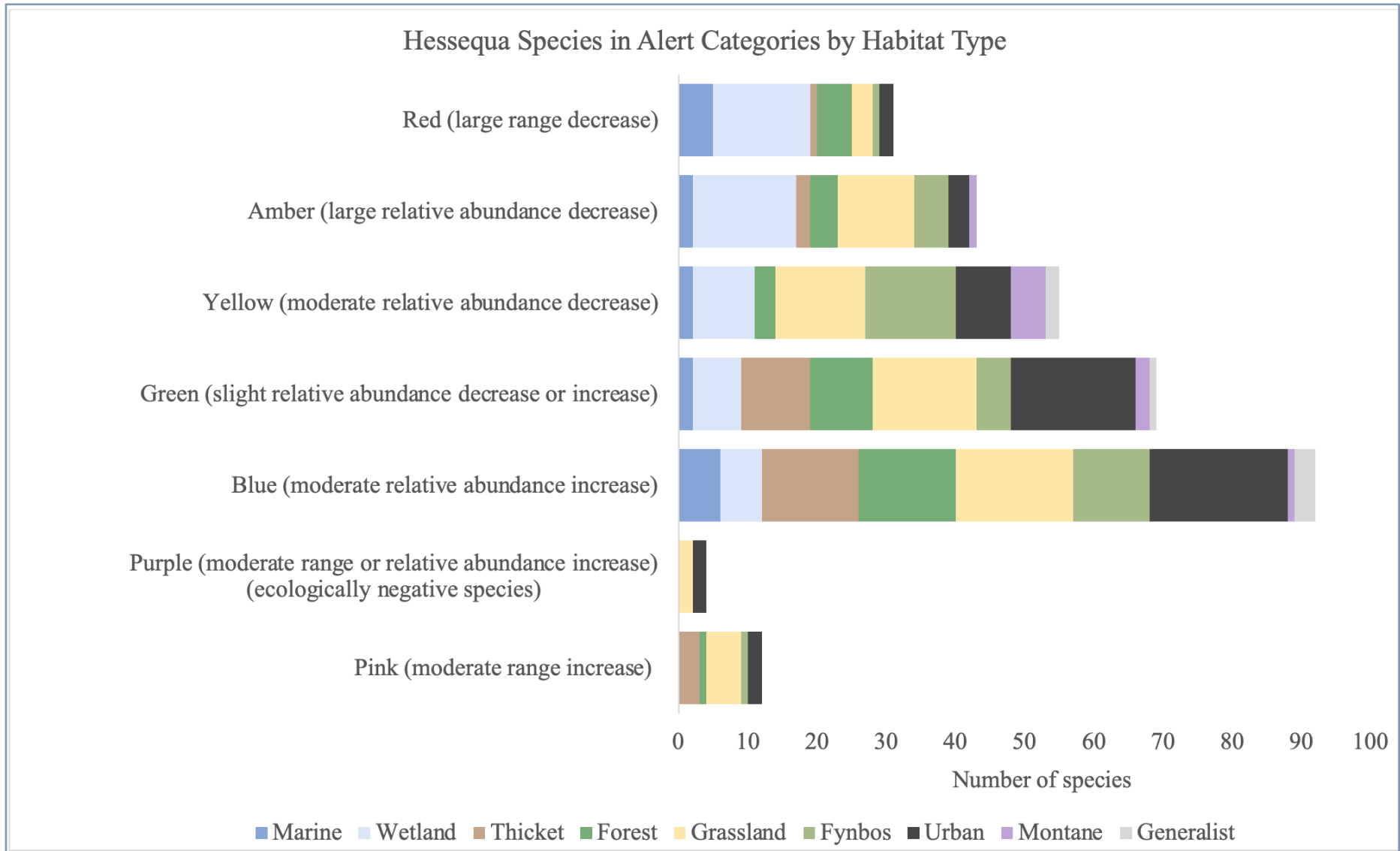


Figure 1. Habitat associations for 165 bird species in the Hessequa Atlas Area, sorted into seven alert categories. Note the greatest concentration of species are those showing stable or slightly increasing populations, and populations decreasing in range and relative abundance are predominantly Wetland, Marine, and Grassland associated.

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CHAPTER 5

The human dimensions of citizen science: Assessing participant relational values in two African Bird Atlas Projects



*There is intelligence embedded in our languages and cultures
which science catches up with.*

Krista Tippett

Abstract

Biodiversity monitoring is a participatory endeavour; everyone affected by the biodiversity crisis can be considered an environmental actor with valuable and necessary contributions to make towards local monitoring. Citizen science provides an inclusive and democratic platform for non-scientists to contribute to conservation science. While the motivations of citizen science participants have been extensively considered, the values participants hold towards non-human nature remain largely unexplored. In particular, relational values, which are typically abundant and cover a broad spectrum of potential human-nature linkages, may offer important insights into where participants find meaning in non-human nature, and whether participation in citizen science shapes or interacts with values. Crucially, these explorations assist practitioners in understanding the values underlying participant motivation, and how these may be supported and harnessed to maximise participant and project benefits. In this chapter, I use conversational interviews to describe the value profiles of citizen science participants and non-participants in two communities: Stilbaai, South Africa, and Jos, Nigeria. I then apply a recently developed framework to explore the relational values of interviewees in greater depth. I ask the following two questions: Does the type and frequency of values (instrumental, intrinsic, and relational) differ between participants and non-participants, and between cultural contexts?, and what relational values (if any) are linked to participant motivation? Results show the importance of relational values of knowledge, stewardship and responsibility, and attachment to places and natural entities in mediating relationships to nature for all interviewees. Other important values were linked to identity, aesthetic/inspirational, and psychological/therapeutic meaning. Participant motivations strongly overlapped with values of knowledge, stewardship and responsibility, and social relationships. These results highlight the importance of considering plural valuations of nature in social-ecological systems and demonstrate the potential for relational values to inform both citizen science and conservation practice.

1. Introduction

While biodiversity conservation policy is best informed by data, the ecosystems which conservation seeks to protect include humans, and neglecting to incorporate the complex human individual into conservation work constitutes both a scientific and an ethical failing. From a scientific perspective, the success of policy interventions is ultimately determined at the local scale, in the values and actions of individual people and communities (Barry & Oelschlaeger 1996; Keane et al. 2008; Cook et al. 2013; Toomey et al. 2017; Githinji et al. 2023). Thus, failure to take these individual people into consideration challenges the efficacy of policy. From an ethics perspective, omitting the human dimensions of ecosystems from conservation is a moral injustice. Humans are integral components of the ecosystems they inhabit (Schultz 2002; Caillon et al. 2017; Lehtonen et al. 2018), and, in the interest of crafting effective conservation measures, should receive equal consideration in assessments and interventions. This realisation sets a new precedent; conservationists are asked to develop tools for understanding the people of ecosystems both as complex individuals and environmental actors (Brown 2003; Redpath et al. 2013; Whitehead et al. 2014; Bennett et al. 2017; Sanborn & Jung 2021). Categories of value have garnered particular attention in this regard, leading to the development of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) framework for assessing values (Díaz et al. 2015). Within conservation, an assessment of values can be considered an attempt to sketch a nuanced profile of personal meaning for the individual as part of a complex ecosystem. There is growing support for the place of values as ‘deep’ leverage points; most current conservation interventions target tangible but shallow leverage points, incapable of generating long-term transformation (e.g. Abson et al. 2017; Fischer & Riechers 2019; Leventon et al. 2021a,b; Riechers et al. 2021; Gaston et al. 2023). Values, while nuanced, idiosyncratic, and intangible, are deep-seated within individuals and communities, and values-directed conservation may support the long-term effectiveness of interventions through seeking to understand what is important to individuals and communities (Jones et al. 2016; Davelaar 2021; Woiwode et al. 2021; Riechers et al. 2022).

Of the three IPBES value categories (instrumental, intrinsic, and relational; cf. Chapter 1), relational values are generally more abundant in individuals than instrumental or intrinsic values (Arias-Arévalo et al. 2017; Klain et al. 2017; Wessels et al. 2021; Uehara et al. 2022), and thus may be stronger leverage points than their counterparts. Citizen science projects offer a unique opportunity to investigate this pattern. Citizen science participants are individuals who act as data collectors for biodiversity monitoring, but are also environmental actors who themselves engage in the conservation of social-ecological systems. Studying the value profiles of citizen science participants, then, may benefit project practitioners, conservation scientists and participants themselves. Practitioners can gain insight into the values underlying participant motivations; these, in turn, can be supported and mobilised to improve the quality of the product (data collected) and the experience (project participation). Likewise, conservation scientists can benefit from learning the values held within a local community, which can be used to shape and direct effective policy intervention.¹

¹ Note that for this to be true, citizen science participant demographics must accurately reflect the demographics of their wider community (cf. [Chapter 2](#), *Challenges to democratic citizen science: Knowledge integration, exclusivity, ethicality*).

However, the value profiles of citizen science participants remain poorly understood. It is unclear which value types are most prevalent among participants, and whether this differs between participants and non-participants. Furthermore, if relational values are particularly abundant among participants, then citizen science practitioners have opportunity to benefit from studying the links between the relational values of participants and their self-expressed motivations for participation in a citizen science project. Thus, this chapter focuses on characterising the value profiles of participants and non-participants of the African Bird Atlas Project (Chapter 1) in two communities: Stilbaai (South Africa), and Jos (Nigeria). I ask the following two questions: Does the type and frequency of values (instrumental, intrinsic, and relational) differ between participants and non-participants, and between cultural contexts?, and what relational values (if any) are linked to participant motivation? I then discuss the most dominant values observed, both in relation to participant motivations and in a broader conservation context, and provide recommendations for future directions of a values-inclusive, interdisciplinary conservation.

Core strengths of relational values

Besides their abundance relative to other value types, relational values carry important ideological distinctions separating them from instrumental and intrinsic systems. Mattijssen et al. (2020) identify three characteristics unique to relational values: An integrative orientation, the notion of irreplaceability, and the acknowledgement of a reciprocal influence between humans and non-human nature. To clarify why these are key strengths of relational values, it is worth exploring the nuanced implications of each distinction.

Integrative

Perhaps the most important development in relational values is the re-framing of humans as part of nature rather than existing as separate from nature. This ideological distinction is crucial in at least two ways: First, envisioning humans as members of a larger system creates the capacity to view responsibility as a value. Though responsibility has been explored as a motivation for conservation behaviour (De Young 2000; Osbaldiston & Sheldon 2003; Dearborn & Kark 2010; Heimann & Medvecky 2022), it may also exist at a deeper level in the relationships between humans and non-human nature. Motivations for responsibility are strongly internalised and linked to identity, social and personal norms, and care (Arpan et al. 2013; Silvi & Padilla 2021; Ejelöv et al. 2022). These concepts are also embedded within relational values. Second, relationships allow space for conflict and unpleasant experiences with non-human nature². As noted by Kaltenborn et al. (2017), Knippenberg et al. (2018), and Bremer et al. (2018), not all relational values are related to positive representations of nature; for instance, a human may value the aesthetic beauty of a canola field, even

²While negative experiences are included within the instrumental value framework of nature's contributions to people (cf. [Chapter 1, Instrumental](#)), only contributions to humans are considered (e.g. Faith 2021). The reciprocity of relational values enables consideration of the impacts of interaction for both human and non-human nature (cf. this chapter, *Reciprocal*).

though the field is part of a monoculture which depletes overall soil quality and supports a relatively poor biodiversity. Likewise, a sheep farmer may value stewardship and caring for the land, and still come into conflict with native predators taking her lambs. Leaving space for complex relational landscapes where two (sometimes conflicting) truths co-exist allows individuals and communities to be heard and understood more completely, rather than relegated to one side of a controversial issue (i.e. agriculture or re-wilding; predator conservation or predator culling). Allowing for this complexity is a first step towards integrating the types of discourse necessary for setting and reaching co-created and sustainable conservation objectives.

Irreplaceable

A second by-product of relationship is the notion of irreplaceability; that is, one subject is not readily substituted for another (Topp et al. 2021). Just as one's grandmother, for example, could not simply be replaced with another grandmother, a human may hold a specific meaning only in the context of relationship with a certain non-human entity. This distinction has implications for commonly utilised policies such as biodiversity offsetting, an attempt to compensate for ecological impacts of human infrastructure development by "replacing" what is lost in one location elsewhere (McKenney & Kiesecker 2010). Despite widespread application (Maron et al. 2016; Bennett et al. 2017; Bull & Strange 2018), the practice of offsetting remains controversial in conservation (Bekessy et al. 2010; Bull et al. 2013). Josefsson et al. (2021) examined 40 offsetting evaluations and found that in every case, biodiversity losses were not sufficiently quantified prior to offsetting, meaning non-instrumental values were neglected or overlooked entirely. The approach has also received criticism for its commodification of non-human nature (Dauguet 2015; Karlsson & Edvardsson Björnberg 2021) and neglect of non-utilitarian valuations (Ives & Bekessy 2015). The absence of supporting evidence for biodiversity offsetting is ethically troubling, but it also points to a need for an understanding of losses and ecological impacts that is inclusive of plural value systems, extending beyond nature's 'use' to incorporate experiences, connections, and interactions with non-human nature (Gardner et al. 2013; Curran et al. 2014; Gonçalves et al. 2015; Maron et al. 2015). Here, relational values offer unique perspective; when the object of replacement is a relationship and not only a service, an offsetting approach is no longer tenable—and relationships are important behavioural motivators in conservation landscapes (e.g. Manfredi et al. 2015; IPBES 2019; Whitburn et al. 2019; Shishany et al. 2020; Tamar et al. 2020). Policy, therefore, is made more effective by taking into consideration the ways in which an ecosystem and its individual components hold meaning for each human. Conversely, policy that approaches the ecosystem solely as a balance in a bank account fails to acknowledge the multiple intangible values built and maintained within the relationships between ecosystem components, and often sets itself up for failure (Ives & Bekessy 2015). Relational values can perhaps lead conservationists towards a higher-resolution understanding of what is important to conserve within a given landscape.

Reciprocal

A third necessary distinction of relational values is their inherent reciprocity. This links closely with both integration and irreplaceability. From a relational perspective, humans exist as part of nature, and thus the influence between humans and non-human nature may be considered mutual. This brings two contributions to conservation: First, it broadens the underdeveloped scientific lexicon of human contributions to nature, and

second, it grants agency to non-human components as equal partners and contributors towards ecosystem survival (not only human survival). Historically, conservation literature has been characterised by a lack of documentation regarding the scope and range of human contributions to non-human nature, focusing largely on the negative. Though important, negative contributions are only a single dimension of multidimensional relationships, as evidenced by more recent research in subdisciplines such as biocultural conservation (Caillon et al. 2017; Bridgewater & Rotherham 2019; Merçon et al. 2019). Looking outside of scientific literature, Indigenous Peoples have a long and storied understanding of humans as contributing members of a larger system, capable of positive, negative, and neutral interactions (Salmón 2000; Diver et al. 2019; Ojeda et al. 2022; Turner et al. 2022). The relational values framework may enrich scientific discourse and policy by giving voice to the insights and ecological wisdom of the humans whose history is grounded in reciprocal partnership with non-human nature (Ens et al. 2016). Second, reciprocity can question the implications of mutual influence between humans and non-human nature and leaves space for components of non-human nature to exist as Subject rather than Object (Naveh & Bird-David 2013; Kimmerer 2013; Hornborg 2017; Conty 2022). This offers opportunities to explore the relational ontologies supporting the partnerships embodied in Indigenous practices. These diverse ways of knowing and co-existing enrich the democratic reach of conservation, and braid together, at a critical juncture in conservation literature, strands of religious, spiritual, and scientific thought (Sponsel 2011; Rountree 2012; Herriman 2018; Rautio et al. 2022).

2. Materials and methods

To learn the value profiles of citizen science participants, I conducted in-depth, semi-structured conversational interviews in Stilbaai and Jos. In each location, two categories of interviewees were distinguished: Citizen science participant and non-citizen science participant. Interviewees were selected in such a way as to minimise demographic differences between the two groups. Semi-structured conversational interviews³ were used to provide consistent and comparable questions to each interviewee whilst also leaving space for interviewees to share stories or insights around the topics of discussion (Chapter 1). I conducted interviews via Zoom video or audio calls, which ranged in length from 12 minutes to 55 minutes. I transcribed the resulting audio files via Temi voice-to-text software (temi.com), and then proofread and corrected the transcripts manually. Using the Riechers et al. (2022b) relational values framework and including separate categories for instrumental and intrinsic values, I created a code system in MAXQDA (VERBI Software 2021). I was assisted in coding by master's student Sina Vargas, who coded the Jos interview transcripts. Sina and I coded and compared test interviews twice, once at the beginning and then again during the coding process and worked together throughout to maintain inter-coder reliability between transcripts.

³ A list of interview questions is available in [Appendix A](#).

Study sample selection

Interviewees in both South Africa and Nigeria were selected on the basis of their participation in an African Bird Atlas Project (Chapter 1), either the Second Southern African Bird Atlas Project (SABAP2) or the Nigerian Bird Atlas Project (NiBAP). Atlas projects were chosen for a number of reasons: First, as one of the longest-running bird atlas projects in the world, SABAP2 has already served as the subject of research examining participant motivation (e.g. Wright et al. 2015; Lee & Nel 2020; Rose et al. 2020), providing some context for distinguishing between participant motivations and values. Second, the inclusion of both SABAP2 and NiBAP provided a unique opportunity to examine value landscapes in two cultural contexts, and perhaps gain insight into the relative importance of different values in each context. Third, as established and growing initiatives, both SABAP2 and NiBAP offered a sufficient body of participants to interview in order to detect meaningful patterns. An equivalent number of non-citizen science participants were also selected and interviewed in each context to allow for value comparisons between participants and non-participants.

Interviewees were informed about the purpose of the study and the data management plan for this project, and afterwards submitted signed consent forms, issued under University of Cape Town ethics clearance permit FSREC 049 – 2021. In both Nigeria and South Africa, one person coordinated the distribution of consent forms and interviewee recruitment. Interviewees were contacted via email and invited to participate in an interview; interested respondents returned their signed consent forms, and I scheduled interviews based on respondent availability. All interviews were conducted and recorded via Zoom, due to travel restrictions imposed by the COVID-19 pandemic. Interviewees consented to audio and/or video recording of interviews and were invited to provide verbal confirmation again before beginning recording. Interview participation was strictly voluntary and was not compensated in any way.

South Africa: SABAP2 in Stilbaai

Interviewees in South Africa were based in Stilbaai, Western Cape. 17 citizen science participants and 15 non-participants were interviewed.⁴ All interviewees were members of the local University of the Third Age (U3A) Stilbaai Bird Group; all selected interviewees had participated in a basic bird identification course offered through the Bird Group. Thus, all interviewees had at least some pre-existing interest in non-human nature, though only the 17 citizen science participants were actively involved in SABAP2.

Nigeria: NiBAP in Jos

Interviewees in Nigeria were based in Jos, Plateau State. Eight citizen science participants and eight non-participants were interviewed. 14 interviewees were graduates or current students at the A.P. Leventis Ornithological Research Institute (APLORI), with a minimum of an undergraduate bachelor's degree in ornithology, conservation, or a related field. The remaining two did not have backgrounds in conservation but were employed at APLORI. Since all interviewees were university-educated and either working in or studying

⁴ Basic demographic information of interviewees is available in [Appendix A](#).

nature-related fields, it can be assumed that all interviewees had a similar baseline level of familiarity with and interest in non-human nature. As in Stilbaai, though, only the eight citizen science participants were actively involved in NiBAP.

Interview protocol and structure

The conversational interview protocol was based on a set of questions I developed in 2021. Questions were selected to elicit value-rich responses, whether instrumental, intrinsic, or relational. The interview protocol was trialled and refined through a series of test interviews before it was finalised. I used a narrative and conversational interview style (cf. Chapter 1), beginning by asking interviewees to describe their history with nature, and then guiding the ensuing conversation with specific follow-up questions. In all questions, the term ‘nature’ was intentionally left to the interviewee to define. This was to avoid leading interviewees to describe themselves as part of or distinct from nature—a key distinguishing feature between instrumental, intrinsic and relational values (cf. Chapter 1, Figure 2). Although one question specifically sought a relational value response (*If you close your eyes and picture it, how would you describe the relationship between yourself and nature?*), all other questions left space for respondents to express instrumental or intrinsic values as well (i.e. *What do you appreciate about nature?*). This allowed me to examine the frequency of relational value statements in relation to instrumental and intrinsic value statements. Because I could not estimate how many relational values interviewees would express (relational values were assumed, but not known, to be more abundant than instrumental or intrinsic), a question targeting relational values was included to ensure at least one relational value response per interview, should the starting assumption prove false. Responses to this question would then guarantee an opportunity to examine participant relational values in greater depth by applying the relational values framework. A final question, *What is your motivation to participate?*, was asked only of citizen science participants. Responses to this question were used to determine the citizen scientist participant motivations examined in connection to relational values.

Relational values framework

The values framework, based on the work of Riechers et al. (2022b), consisted of nine primary value categories: *Identity, Heritage & Tradition, Social Relationships, Attachment to Places & Natural Entities, Stewardship & Responsibility, Knowledges, Spiritual & Religious, Aesthetic & Inspiration, and Psychological & Therapeutic*. Primary categories contained 19 nested sub-categories, and 11 sub-sub-categories (Table 1).⁵ I built the framework into MAXQDA (VERBI Software 2021) as a custom code set, and coded interview transcripts statement by statement for relational values. I used an iterative approach to coding, re-visiting each interview multiple times throughout the coding process as I developed clearer definitions for categories and sub-categories. Through the coding process, I added the sub-sub-categories *Shared* and *Personal Environmental Learning* to accommodate observations. The sub-sub-category *Personal Environmental Learning* describes knowledge values which are individual, and not necessarily linked to social or group learning processes, and

⁵ For descriptions of each category, sub-category, and sub-sub-category, refer to Riechers et al. (2022b).

Shared Environmental Learning explores values linked to shared learning with other individuals, communities, and social groups. I also created codes for value statements which could be classified as either Instrumental or Intrinsic (subcategories such as nature's contributions to people were not specified, as I was interested primarily in relational values). Finally, I created a separate code for 'action statements' and assigned it to value statements linked to a specific conservation-oriented behaviour. This code was included retrospectively out of interest rather than as an intentional component of the study design, because the interview protocol did not explicitly target behaviour.

Quantitative data analysis

Because of the small interview sample size (N =48), I used Fisher exact tests with two-sided alternative hypotheses (Hirji et al. 1991) to examine the relationships between value code frequencies among the four interview groups: Citizen science participants and non-participants, and Nigeria and South Africa. I used the code frequency analysis tool in MAXQDA (VERBI Software 2021) to identify the sub-categories and sub-sub-categories that appeared in at least 25% of the 48 interviews. I created 2×2 contingency tables for the 20 resulting categories, comprising the number of interviewees who mentioned each value category and the number who did not mention the category in each comparison group. I also created contingency tables for *Instrumental* and *Intrinsic* value codes.

Qualitative data analysis

I analysed the coded interview transcripts thematically to identify distinctions in relational values and values intersecting with motivations between interview groups. Sample statements were selected to represent the overarching themes that emerged for each group. Additionally, I examined coded statements for each interview group using the Code Relations Browser tool in MAXQDA (VERBI Software 2021) to detect significant overlaps and intersections between different value categories.

3. Quantitative results

A total of 1178 value statements were coded; 726 for citizen science participants (537 South Africa, 189 Nigeria), and 452 for non-participants (298 South Africa, 154 Nigeria). 1101 relational statements were coded across 32 interviews, 695 for citizen science participants (528 South Africa, 167 Nigeria), and 406 for non-participants (276 South Africa, 130 Nigeria). A total of 55 instrumental value statements were coded across 26 interviews; 23 statements for citizen science participants (in two out of 17 interviews in South Africa, seven of eight in Nigeria) and 32 for non-participants (in 11 out of 15 interviews in South Africa, six of eight in Nigeria). Instrumental value statements were more common among non-citizen science participants than among participants, and among Nigerian interviewees than South African (Table 3). A total of 22 intrinsic value statements were coded across 11 interviews; eight for citizen science participants (one out of 17 interviews in South Africa, two of eight in Nigeria) and 14 for non-participants (five out of 15 interviews in South Africa, three of eight in Nigeria).

The most common relational categories to emerge for citizen science participants were *Stewardship & Responsibility* (146 codes; 16 out of 17 interviews in South Africa, seven of eight in Nigeria), *Knowledges* (204 codes; 16 out of 17 interviews in South Africa, eight of eight in Nigeria) and *Attachment to Places & Natural Entities* (102 codes; 17 out of 17 interviews in South Africa, six of eight in Nigeria). For non-participants, *Aesthetic & Inspiration* (54 codes; 13 out of 15 interviews in South Africa, six of eight in Nigeria), *Knowledges* (80 codes; 14 out of 15 interviews in South Africa, seven of eight in Nigeria), *Stewardship & Responsibility* (72 codes; 13 out of 15 interviews in South Africa, seven of eight in Nigeria), *Psychological & Therapeutic* (33 codes; 12 out of 15 interviews in South Africa, six of eight in Nigeria), and *Attachment to Places & Natural Entities* (62 codes; 14 out of 15 interviews in South Africa; eight of eight in Nigeria) were the most common relational categories.

30 citizen science participant motivations were reported by 24 participants, and for ease of analysis, these were grouped into twelve broader motivations (Table 4). Four of the twelve motivations were present in both the South African and Nigerian context: Social interactions/meeting like-minded people; learning about nature/conservation; collecting meaningful data; and enjoyment/fun. Local leadership was a motivation for seven participants in the South African context and raising conservation awareness/educating others was a motivation for four citizen science participants in Nigeria. 23 of the 30 original motivations overlapped with one or more value(s). All coincided with either *Knowledges* (13), *Stewardship & Responsibility* (nine) or *Social Relationships* (eight) values. A few motivations additionally coincided with *Aesthetic & Inspiration* (three), *Attachment to Places & Natural Entities* (one), or *Spiritual & Religious* (one) values.

Identity

Value statements linked to identity appeared with equal frequency in all four interview groups (Figures 1 & 2). They were present in 18 interviews with citizen science participants (72%) and 17 interviews with non-participants (74%). Identity values were present in 24 interviews in South Africa (75%) and 11 interviews in Nigeria (69%). In both cultural contexts, the subcategory *Individual* was most common; this same sub-category was slightly more common in Nigeria and among citizen science participants, but these differences were not statistically significant (Figure 4; Table 3). The sub-category *Social, Community & Collective* was slightly less common (Table 3), though statements were coded in all four interview groups. No statements were coded for the sub-category *Cultural* or its sub-sub-category, *Sovereignty* (hence their omission from Figures 3 & 4).

Heritage & Tradition

Value statements linked to heritage and tradition were unevenly distributed among cultural contexts and citizen science participants/non-participants (Figures 1 & 2). Values within this category were more common in the South African context than Nigerian (Figure 4), and there was no significant distinction between citizen science participants and non-participants (Table 3). The sub-category *Tradition* appeared most frequently among citizen science participants and in South Africa, though only present in a small fraction of interviews (32% for participants, 31% for South Africa). This sub-category was also the only value linked to heritage and tradition that was coded in the Nigerian context, appearing in a single interview. The sub-sub-category *Social Memory* appeared only in the South African cultural context (11 interviews, 34%; Table 3), most commonly among

citizen science participants (5 interviews, 20%). Few statements were coded in the remaining sub-categories and sub-sub-category in any interview group.

Social Relationships

Values linked to social relationships were more common among citizen science participants (22 interviews, 88%) than non-participants (13 interviews, 57%). There was no significant difference detected between South Africa and Nigeria (Table 3). The sub-category *Social Relations* was most frequently coded, though very few statements were coded under its sub-sub-category, *Social Bonds*. The sub-category *Social Cohesion* featured more prominently in the Nigerian cultural context (seven interviews, 44%) than South African (five interviews, 16%), though neither of its sub-sub-categories, *Sense of Community* or *Sense of Belonging*, were coded in any Nigeria interviews, and occurred in only a few statements in other interview groups.

Attachment to Places & Natural Entities

Values linked to attachment to places and natural entities were among the three most common value categories across all interview groups (Figures 1 & 2). In particular, the sub-category of *Conviviality & Friendship* was coded in most interviews for all groups, though for somewhat fewer non-citizen science participants (Figure 3). The sub-category *Kinship* was most common among citizen science participants and was represented in 10 interviews (31%) in the South African context and four interviews (25%) in the Nigerian context. The sub-category *Sense of Place* was coded for over half of the interviews in South Africa and was significantly less common in Nigeria (Table 3). Its sub-sub-category, *Regional Identity*, was not coded in any Nigeria interviews, and only in small numbers for the remaining three groups.

Stewardship & Responsibility

Values linked to stewardship and responsibility were the third most common value type among all four interview groups (Figures 1 & 2). The sub-category *Care & Stewardship* was especially prominent, appearing in 21 interviews with citizen science participants (84%) and 17 with non-participants (74%), as well as 28 interviews in South Africa (88%) and 10 in Nigeria (63%) (Figures 3 & 4). Its sub-sub-category, *Reciprocity*, was significantly most prominent in the Nigerian context than South African (eight interviews, 50%; Table 3). The sub-category *Social Responsibility* was most prevalent among citizen science participants (14 interviews, 56%) and in the South African context (18 interviews, 56%) and was only slightly less common among non-participants (12 interviews, 52%) and in the Nigerian context (eight interviews, 50%). Its sub-sub-category, *Bequest*, was most common among citizen science participants, appearing in five interviews (20%), and the Nigerian cultural context, appearing in three interviews (19%). Only four interviews in the South African context (12.5%) and two interviews with non-citizen science participants (9%) were coded for *Bequest* values.

Knowledges

Values linked to knowledge were the most prominent in all interview groups, appearing in 24 out of 25 (96%) interviews with citizen science participants, 21 out of 23 (91%) interviews with non-participants, 30 out of 32 (94%) interviews in the South African context, and 15 out of 16 interviews (94%) in the Nigerian context

(Figures 1 & 2). The sub-category *Environmental & Ecological Systems Knowledge* was most prominent in the Nigerian cultural context (11 interviews, 69%), and was slightly less common in the remaining three interview groups (Figures 3 & 4). The sub-sub-category *Personal Environmental Learning* was common in all interview groups, especially in the South African context (25 interviews, 78%) and among citizen science participants (20 interviews, 80%), and to a somewhat lesser extent in the Nigerian context (11 interviews, 69%) and among non-participants (16 interviews, 70%). The sub-category *Indigenous & Local Knowledges* were significantly more common among citizen science participants than non-participants, and were more common in the South African context than in Nigeria (Table 3). The sub-sub-category *Shared Environmental Learning* was not coded in any interviews in the Nigerian context, and thus was significantly more common in the South African context (26 interviews, 81%) in the South African context (Table 3). Hence, the prominence of this sub-category among citizen science participants (13 interviews, 52%) and non-participants (11 interviews, 48%) was limited to the South African context.

Spiritual & Religious

Values linked to the spiritual and religious appeared in roughly half of all interviews in South African and Nigerian cultural contexts (19 interviews, 59% and 8 interviews, 50% respectively). They were slightly more common among citizen science participants (16 interviews, 64%) than non-participants (11 interviews, 48%) (Figures 1 & 2). The sub-category *Spiritual Fulfilment* was most common, and was coded in 15 interviews (60%) with citizen science participants, eight interviews in the Nigerian context (50%), and 15 interviews in the South African context (47%) (Figures 3 & 4). This sub-category was slightly less prevalent among non-citizen science participants, appearing in only eight interviews (35%), but the difference was not statistically significant (Table 3). The sub-categories of *Religious* and *Sacred* values were coded in less than 30% of interviews in any of the four interview groups.

Aesthetic & Inspiration

Values linked to aesthetics and inspiration were of roughly equivalent importance among citizen science participants (20 interviews, 80%) and non-participants (19 interviews, 83%), and were more common in the South African context (29 interviews, 91%) than the Nigerian context (10 interviews, 63%) (Figures 1 & 2). The sub-category *Aesthetic* was significantly more prevalent in the South African context (28 interviews, 88%) than in the Nigerian context (seven interviews, 44%) (Figure 4; Table 3). It appeared in 16 interviews (64%) with citizen science participants and 19 interviews (83%) with non-participants. The sub-category *Inspiration* featured in less than 25% of interviews in all four groups.

Psychological & Therapeutic

Values linked to the psychological and therapeutic were equally common across all four interview groups (Table 3), and were coded in 19 interviews (76%) for citizen science participants, 18 interviews (78%) for non-participants, 25 interviews (78%) in the South African context, and 12 interviews (75%) in the Nigerian context (Figures 1, 2, 3 & 4). There are no sub-categories for this value type.

4. Qualitative results

Across all groups and all value categories, idiosyncrasy remained a common thread. Comparison of individual value profiles, even for individuals within the same interview group, demonstrated the personal nature of values. However, some patterns did emerge across interview groups.

Instrumental & intrinsic values

Significant overlaps were observed in the instrumental values expressed by interviewees in all interview groups, although no instrumental or intrinsic values were linked to motivations for citizen science participants.

Interviewees frequently referenced ecosystem services such as pollination and food provision. In the Nigerian context, instrumental values were closely linked to values of *Reciprocity* (i.e. statements such as “*nature needs me, and I need nature*”), and a general sense of being directly impacted by harm to non-human nature. Among non-citizen science participants in both Nigeria and South Africa, interviewees identified the role of nature in supporting a human economy, e.g. through job creation and ecotourism. In the South African context, only two citizen science participants expressed instrumental valuations of nature, and both of these described ecosystem services. Non-participant interviewees in South Africa most frequently referenced instrumental valuations of nature as a place for activities and recreation.

Of the intrinsic value statements made by interviewees, all referenced a ‘right to live’ for non-human nature. One citizen science participant in Nigeria described valuing his own inability to control or deny nature’s existence; a non-participant found value in the uniqueness of nature as something that cannot be bought and can only be valued through time spent with nature. Only in the South African context did interviewees describe the intrinsic value of nature in the context of nature being better off without humans. Non-participants in South Africa also named enjoying a sense of not being the most important thing in the universe, and being an outsider looking in on a beautiful world. The term ‘respect for life’ was also unique to the South African context, and was mentioned by two non-participants and one citizen science participant. One non-participant also linked intrinsic value to *Sacred* relational value, describing the sacred role of every organism in an ecosystem.

Knowledges

The most important relational values for all four interview groups were the primary categories of *Knowledges*, *Stewardship & Responsibility*, and *Attachment to Places & Natural Entities*. Other important categories were *Identity*, *Aesthetic & Inspiration*, and *Psychological & Therapeutic*. In statements coded for *Knowledges* values, all interviewees expressed values arising from following curiosity or interest, whether independently or as a group, and a sense of fascination with nature:

“...as I'm walking along the road, I'm observing plants, I'm observing birds, I'm observing interactions in nature generally. I literally spend my whole day. In the night, I try to stay up late into the night to hear bird calls--nocturnal birds--and maybe try to see if I could identify nocturnal insects, too. I'm generally just curious.” (Nigeria NCS 7, Pos. 30)

Such statements were frequently accompanied by descriptions of how understanding one dimension of nature led to a deeper appreciation of or interest in others. Among Nigerian interviewees, values of deepening understanding and learning about nature were linked to educational background. Many described how an education in the natural sciences enriched their personal experiences with nature:

“...as a biologist, I can understand it. I know what's going on and I can just enjoy it. I see what [the ecosystem] is doing, I see how it's contributing to my life, my livelihood. Being able to understand that and enjoy it is what I appreciate most about nature.” (NiBAP CS 4, Pos. 38)

Whilst personal and shared curiosities about nature were frequently referenced by interviewees in all groups, citizen science participants in particular articulated valuing passing on nature knowledge and/or learning from others. Although citizen science participants and non-participants both emphasised shared learning, non-participants tended to place more emphasis on receiving knowledge than sharing knowledge. Interviewees in this group described valuing how knowledge, whether from another person or from a field guide, enabled them to identify species:

“I like to identify the birds in my environment. That's what I took the [bird identification] course for, it gave us the birds that are most prevalent in this area. Those are the ones that I look at, I try to identify them.” (Stilbaai NCS 10, Pos. 150)

In South Africa in particular, knowledge value statements frequently overlapped with *Social Relations* values. These knowledge values were expressed in the context of learning with family or friends, often as a way of bonding with a spouse, neighbours, children, or grandchildren:

“...[birding] is our special time that we do together...it's wanting to go out and wanting to share it with [my spouse].” (SABAP2 CS 5, Pos. 129)

“...our two grandchildren...we've now got Faansie's book⁶...I am ready to learn with them again, to teach them and to experience it with them.” (Stilbaai NCS 2, Pos. 90)

Stewardship & Responsibility

In statements coded with *Stewardship & Responsibility* values, interviewees conveyed concern about nature's wellbeing in relation to identity (e.g. nature is part of me, therefore I care about nature) or conviviality (e.g. nature is like a friend to me, therefore I care about nature):

⁶ “*Faansie's Bird Book*,” a field guide to southern African birds designed specifically for children (<https://faansiepeacock.com/kids-bird-book-2/>).

“If I take care of my house and keep it neat and tidy, that's okay; but I also want to keep the area around me. I want to take care of that, because that's also part of me. If I go down to the beach, I'm part of the beach then, and I'll take care of it in whichever way I can, because I feel responsible to take care of nature...in a way, I want to ask the earth to forgive us [for] what we're doing to it.” (SABAP2 CS 2, Pos. 47)

“I feel like nature is part of me. It's just like you have kids at home--your own kids, you know? You will not allow anything to happen to them; you always want to look back and make sure that everything is okay for them, [that you've] provided everything for them. It is the same thing with me. The advocacy is there for people to understand that this nature is also part of us, that we're meant to live with them.” (NiBAP CS 5, Pos. 40)

In these statements, interviewees express care arising from a closeness with non-human nature, either identifying with non-human nature directly, or relating to non-human nature as a separate but integral component of human life. Though these values cannot be equated with conservation action, codes in the sub-category *Social Responsibility* and its sub-sub-category, *Bequest*, paired with action statements (value statements linked to conservation-oriented behaviour) in six interviews. Behaviours ranged from picking up microplastics on a local beach and collecting rubbish along roadways to a decision to stop hunting native birds. Some behaviours described advocacy on behalf of a species or nature generally:

“...there's a relationship between the children and the forest. The two of them, they are young, and they grow. They need all the love, all the tender care that they can get. And that is why we must always conserve our forest; not because of us, but because of the ones coming behind us. I am 26 years old, and there [are] some animals I won't get to see. At 26, if I won't get to see those animals, then when I give birth to my own children, are they going to see those animals? I'm going to take them to the museum to see a photograph of the gorilla when I cannot take them to the forest, on a safari to see a gorilla. This is why we will not stop talking. We will not stop talking about conservation. It's very important over our lives; it is very important.” (Nigeria NCS 1, Pos. 80)

The sub-sub-category *Reciprocity* appeared more frequently in the Nigerian context than any other interview group. Statements in this category all described mutual influence between humans and non-human nature, and a sense of co-dependent existences:

“I believe that when we treat nature well, nature also is going to treat us well. Because we need nature to survive [and] nature also needs us to survive. It's just like us and the plant; what we release is what the plant takes, and what the plant releases is what we take...As we breathe in, breathe out, we are giving to ourselves.” (Nigeria NCS 4, Pos. 4)

“...without nature, I myself am without. I see it like this: I survive, nature survives. Nature survives, I survive. It is a mutual thing, that nature needs me, but most importantly, I need nature.” (NiBAP CS 1, Pos. 50)

Attachment to Places & Natural Entities

For values of *Attachment to Places & Natural Entities*, some differences emerged in interview transcripts between citizen science participants and non-participants and cultural contexts. For instance, many Nigerian interviewees referred to nature as a plural subject, “they” or “them,” while nearly all South African interviewees referred to nature as an object, “it.” This difference was also reflected in the ways interviewees in each cultural context expressed care for non-human nature. In Nigeria, multiple statements coded as *Conviviality & Friendship* included a dimension of empathising with non-human nature, while in South Africa, statements assigned the same code tended to describe appreciating physical closeness with non-human nature. To illustrate the distinction, consider this statement from a NiBAP participant interviewee:

“...when you hike sustainably, you can take your trash with you. You can afford to be less noisy, because it's just like you being in your house and then someone [comes] banging on your door or shouting—you can just imagine how uncomfortable you'll be.” (NiBAP CS 1, Pos. 32)

This value statement is closely linked with *Identity* and viewing humans as a part of nature, and makes use of empathetic imagination to create a sense of closeness with other entities. In South Africa, while some *Conviviality & Friendship* codes did coincide with *Identity*, more interviewee statements were associated with *Aesthetic* values and a sense of physical closeness, i.e. being pleased by the presence of a beautiful bird in the garden or the trees in a local forest:

“We're enchanted by all the many different trees and how beautiful they are and how wonderfully they grow...we are like little ones: ‘look here, look here! Look at that beautiful tree, look at that beautiful tree!’ We just can't have enough of all those beautiful trees.” (Stilbaai NCS 5, Pos. 40)

“I like the pleasure of nature, of seeing it and walking in it, going through it, living with it.” (Stilbaai NCS 12, Pos. 152)

Though a few interviewees in South Africa did describe themselves as integrated within nature, this language was more common in the Nigerian context, where many interviewees expressed a “cordial” relationship and a sense of co-habiting with non-human nature in a shared home.

Values in the *Heritage & Tradition* category were absent in Nigeria interviews, but were present in 19 out of 32 interviews (59%) in the South African context. In 18 of those 19 interviews, *Heritage & Tradition* values coincided with values of *Attachment to Places and Natural Entities*. Several South African respondents described an allegiance to a particular “home” landscape in South Africa, i.e. the Karoo, Bushveld, Fynbos, or Strandveld, frequently associated with positive childhood experiences and family traditions such as camping,

hiking, hunting, or farming. Many of these statements also intersected with *Aesthetic & Inspiration* values. These broad place associations contrasted with the responses of interviewees in Nigeria; though many did mention childhood experiences in nature, few of these were linked to places, and only one to tradition or heritage. Instead, these were more often tied to *Knowledge, Care & Stewardship* or *Conviviality & Friendship* values.

Identity, Aesthetic & Inspiration, and Psychological & Therapeutic

Identity values were equally present in all four interview groups, but differences arose in the interview texts between the South African and Nigerian statements surrounding *Individual* identity. Of the nine interviews coded for *Individual* identity values in Nigeria, all nine expressed an integration of nature and self, evidenced in the following two statements:

“I appreciate almost everything in nature. I’m part of it myself; by appreciating nature, I’m also appreciating myself.” (NiBAP CS 2, Pos. 32)

“I’m very much part of nature. I depend on everything out there, and I also contribute to the survival and the existence of everything out there—at least by my positive behaviour... I have a big role to play, so there’s no barrier at all; entirely together.” (Nigeria NCS 7, Pos. 58)

Among Nigerian interviewees, this was the case regardless of citizen science involvement. In South Africa, however, there were a mix of statements, with seven out of 17 interviewees describing integration, and the remaining 10 describing feeling close to but separate from nature:

“One has to live with it—I mean, you can’t live without nature. I can’t live without being out, seeing plants, seeing birds, being interested.” (Stilbaai NCS 10, Pos. 72)

“I certainly see myself as an outsider looking in to an incredible world; I’m desperately blessed to have the opportunity, but I try not to disturb as much as possible.” (Stilbaai NCS 6, Pos. 44)

There was also a distinction between citizen science participants and non-participants in South Africa; five out of seven citizen science participants described a feeling of integration with nature, but only two out of ten non-participants.

For *Aesthetic* values, the divide between citizen science participants and non-participants was clearer in Nigeria than South Africa, with one of eight NiBAP participants mentioning beauty as a component of their relationship with nature, and six out of eight non-participants. Non-participants in both Nigeria and South Africa mentioned colours, landscapes, and skylines as particularly meaningful. Notably, several citizen science participants in both countries perceived beauty in technical ways, with six out of 16 describing the complexity of ecosystem interactions, behaviours, or habitats as “beautiful” (see Figure 5).

One of the greatest distinctions to appear in interviews between cultural contexts was that in South Africa, but not in Nigeria, *Aesthetic* value statements were often attached to specific places:

“...we live in Hessequa; we've atlated everywhere, but in Hessequa specifically we've got such beautiful places. It's always a big pleasure to go out and have not only the birds, but also the views.”
(SABAP2 CS 4, Pos. 114)

“We live in a beautiful country...I belonged to a hiking club in which we visited many, many places in our country on hiking trips...we would take our backpacks and go and hike for a week or for two weeks in various parts of our country, which is where you experienced the natural beauty of the Eastern Transvaal, where you experienced the beauty of the Drakensberg mountains in summer and in winter.”
(Stilbaai NCS 3, Pos. 16)

These statements mirror the patterns identified in South African values of *Sense of Place* and *Regional Identity*; interviewees in this cultural context attached more value to specific regions and landscapes, whereas in Nigeria, the value was largely attached to the ecosystem concept or specific entities, regardless of region or landscape (cf. *Attachment to Places & Natural Entities*).

Finally, for *Psychological & Therapeutic* values, the most common themes to emerge included a sense of escape, peace, quiet, calm, or relaxation, space to think, reflect, exercise and de-stress, finding solace in a system that is just “being” or in doing nothing (see Figure 6). Some participants directly referenced the therapeutic effects of nature in their lives:

“...it helps me get out of my head with a lot of issues. It's more like [an] antidepressant for me. Sometimes [if] I feel depressed or down, I just walk around, walk out of my apartment, observe nature. It distracts me from whatever I'm feeling at that point in time, it helps me to relieve pressure. Also, it helps me to get fresh ideas on what to do. It just gives me that serene environment to think.” (Nigeria NCS 7, Pos. 38)

The values described in this category were the most similar among all interviewees, regardless of cultural context or citizen science participation.

Relational values and citizen science participant motivations

Citizen science participant motivations were complex and often linked to multiple relational values. Relational values of *Knowledges* linked to motivation varied within both the South African and Nigerian contexts from one interviewee to the next. Among others, participants described their knowledge-related motivations in terms of continued opportunities to learn, detecting local environmental patterns and understanding the environment from a data-driven perspective. Knowledge motivations also intersected social values, and participants cited interactions with other participants as a source of encouragement:

“My motivation was the people [who] helped me to know a lot about the relationship between nature and we humans...my motivation was relationship, the beauty of it, and also the motivational thought that I got.” (Nigeria NCS 5, Pos. 68)

Values of *Social Relationships* were more often linked to motivation in South Africa than in Nigeria. Yet the social values tied to motivations ranged widely and included valuing local leadership, enjoying meaningful time in nature with loved ones, and working alongside like-minded people to make a difference. Among Nigerian interviewees, *Stewardship & Responsibility* values featured prominently alongside motivation. Interviewees placed emphasis on education and creating awareness as motivations for participation in citizen science:

“I believe in taking personal actions and then explaining to people around me who would care to ask questions. Involvement with NiBAP, I see as an opportunity for partnerships which give a stronger voice to actually changing perceptions about nature, appreciating nature and giving more reasons why there should be conservation.” (NiBAP CS 3, Pos. 94)

“I got motivated by the fact that people like non-scientists are being involved...I think it's an avenue for me to go and make difference, to tell people that this is it: We need to take care of this, and we need to know the status of our birds here in Nigeria.” (NiBAP CS 5, Pos. 68)

Aesthetic & Inspirational relational values linked to motivation were unique to each interviewee, and included enjoying the physical beauty of nature, learning to appreciate ‘common’ species as beautiful through data collection, and feeling inspired to capture the birds and landscapes encountered whilst atlas through nature photography.

5. Discussion

Instrumental, intrinsic and relational values

Though instrumental and intrinsic values were less common among interviewee statements than relational values, these responses are worth exploring. Intrinsic values were scattered and scarce among respondents, and most often linked to *Spiritual & Religious* and *Identity* values. Instrumental values, however, were more common. They were present in 26 of 48 interviews, and there was an observable difference between cultural contexts and citizen science involvement. Most interviewees in Nigeria made at least one instrumental value statement, regardless of citizen science participation. South African interviewees, however, were divided; most non-participants named instrumental values, and most citizen science participants did not. These differences would be useful to explore in relation to environmental education, as Nigerian interviewees may have learned similar instrumental values through their shared educational background at APLORI. Indeed, all of the citizen science participants in Nigeria (and all but one non-participant) referenced instrumental values either within the context of their trained perspective as conservationists, or in the context of educating others. Most of their own values, though, were relational. Among South African interviewees, instrumental values varied in context from ecosystem services to economic contributions, with only one interviewee referring to education or training.

From these results, it seems likely that instrumental values among Nigerian interviewees arose at least in part through their association with APLORI, whilst parallel values in South Africa arose independently among individuals. The distinction between citizen science participants and non-participants is more difficult to disentangle, as it is unclear whether citizen science involvement may play a role in shifting abundance of values, i.e. from more instrumental to more relational, or whether people who participate in citizen science already hold fewer instrumental or more relational valuations of non-human nature (e.g. Kendal & Raymond 2019). Further research—ideally a long-term study assessing values in the same citizen science participants over time—is needed to clarify these distinctions.

Regardless of their origins, plural valuation systems are a known component of social-ecological systems, and thus variation in the types of values present is to be expected (Arias-Arévalo et al. 2017; Bieling et al. 2020; Mulyoutami et al. 2023). Here, the presence of relational values in every interview indicates their importance. This is a pattern reflected internationally (e.g. Arias-Arévalo et al. 2017; Klain et al. 2017; Wessels et al. 2021; Uehara et al. 2022), and the prevalence of relational values versus instrumental or intrinsic raises important questions surrounding the efficacy of instrumental values-focused pedagogy in citizen science and, more broadly, in conservation. Interviews in both Nigeria and South Africa indicate that projects justified entirely on instrumental valuations of non-human nature are incomplete, especially considering that instrumental and intrinsic values were unrelated to citizen science participant motivations in both contexts. From a broader conservation perspective, it is interesting to consider that responses from Nigerian interviewees heavily referenced instrumental values in relation to education, but not necessarily as the values they held themselves. It is possible that these instrumental values are themselves embedded within relational values (e.g. Hakim et al. 2023); again, this would only strengthen the body of evidence for including relational values in the conservation of social-ecological systems. The entanglement of instrumental and relational values observed here also reiterates the importance of looking beyond nature's 'utility' to experiential and connective understandings of the human-nature relationship. While such understandings may fall outside of traditional scientific (and broadly Western) paradigms, they are deeply grounded in many individuals, communities, and cultures (e.g. Manuel-Navarrete et al. 2004; Chilisa 2017), and are thus equally important points for consideration in managing social-ecological systems. For citizen science practitioners, these results indicate that the relational values of participants are closely tied to motivation—much more so than instrumental or intrinsic values. By, for instance, regularly inventorying and tracking participant relational values and motivations, practitioners can learn what aspects of their project are linked to specific values and motivations, and can target 'weak' points to improve participant benefit and/or data quality. For example, if many participants value social relationships with like-minded people, project leadership can organise monthly group outings to support the value, increase participant benefit, and potentially increase participation.

Knowledges

Many individuals stated that their relationships with non-human nature were mediated by a personal interest in observing, learning, and experiencing non-human nature. This agrees with literature findings regarding the importance of learning as a motivator for citizen science participants (Land-Zandstra et al. 2021; Agnello et al.

2022; Sakurai et al. 2022), but also as a relational value regardless of citizen science participation (e.g. Kreitzman et al. 2022). Recall that the sub-sub-category *Shared Environmental Learning* details the process of learning with and about the non-human natural world within groups and communities; the prominence of this category among interview responses is consistent with multiple studies implicating the importance of social learning as a motivation for citizen science participants (Johnson et al. 2014; Richter et al. 2018; Agnello et al. 2022; Day et al. 2022). In this study, the prominent overlap between participant motivations and relational values of knowledge suggests that the shared process of environmental learning is both a motivator and a held value, or perhaps even an interaction of the two: a motivating value.

In the South African context, the importance of the sub-sub-category *Shared Environmental Learning* may be partially explained by interviewee demographics; most South African interviewees were retired from the workforce and several mentioned the importance of learning with their children and grandchildren through nature. Many also started birding and participating in citizen science as a way to connect with other people in their community. Thus, life stage and personal motivation may also contribute to the importance of *Shared Environmental Learning* within a cultural context, and to motivations to participate in a citizen science project.

Overall, the prominence of relational values of knowledge highlights the role of experiential and embodied learning interactions in shaping individual values of non-human nature. Whilst informational knowledge is a known by-product of citizen science participation (e.g. Brossard et al. 2005; Crall et al. 2013; Haywood et al. 2016; Land-Zandstra et al. 2021), relational knowledge remains largely unexplored. The abundance of relational knowledge values in this study adds to growing concerns in conservation regarding barriers to nature access, and the importance of nature experiences in determining conservation-oriented behaviour (Soga & Gaston 2016; Schuttler et al. 2018; Gaston & Soga 2020). If the ability to build knowledge and learn from and within non-human nature is a critical component of the human relationship with non-human nature, then what is the impact of nature impoverishment on that relationship? It seems reasonable to assume that fewer opportunities to build relational knowledge result in fewer relational ties to non-human nature (e.g. Cleary et al. 2020; DeVille et al. 2021), and consequently, a weaker human-nature relationship overall. Further research is needed to understand the interactions between experiences and knowledge, and how these in turn shape behaviour.

Stewardship & Responsibility

Relational values of *Stewardship & Responsibility* in this study illustrate the importance of responsibility as a motivator for actions ranging from removing litter on beaches to environmental advocacy, whether through a sense of moral obligation to non-human nature or to future human generations. This aligns with wider definitions of stewardship, responsibility, and reciprocity values as “roles” entailing an active component of duty or obligation to fulfil (Welchman 2012; van Putten et al. 2014; Enqvist et al. 2018; West et al. 2018). These values were also closely linked to many participant motivations to contribute to citizen science, suggesting that the value of responsibility is an important motivator for participants—another potential ‘motivating value.’ Yet it is important to note that responsibility values do not exist independently; across all interviews, *Social Responsibility* and *Bequest* values were also entangled with *Knowledge*, *Identity*, *Attachment to Places & Natural Entities*, *Care & Stewardship*, *Aesthetic*, and *Psychological & Therapeutic* values. Thus, unravelling the

bonds linking stewardship, action, and citizen science participation requires the incorporation of multiple values, and further research is needed to determine whether stewardship values emerge from within or arise in parallel with others.

The prominence of *Reciprocity* values among interviewees in Nigeria may echo the reflections of Kimmerer (2017), who identified a philosophy of reciprocity inherent in certain Indigenous traditions. In the Nigerian context, it is unclear whether the notion of reciprocity arose as an element of Indigenous or cultural heritage (e.g., McMillan & Prosper 2016; Sheremata 2018; Russell et al. 2020; Turner et al. 2022), or perhaps as a by-product of a shared educational background; recall that all interviewees in Nigeria were affiliated with the A.P. Leventis Ornithological Research Institute. This is an important distinction to understand since values of reciprocity were also closely linked to action statements. Furthermore, if reciprocity values can be traced to educational background (encompassing certain *Knowledge* values), there may be a strong case for teaching a philosophy of reciprocity at the school and university level. Further interviews with a broader community of individuals in Jos and elsewhere internationally may aid in explaining the prevalence of reciprocity values within the cultural context.

Attachment to Places & Natural Entities

For values of *Attachment to Places & Natural Entities*, the observed distinctions between cultural contexts are interesting to note but cannot be reduced to a single causal factor. Stage of life, linguistic heritage, educational background, cultural norms, and socioeconomic status may all contribute to the ways in which each individual relates to non-human nature; thus, tracing observed differences to a particular source would prove a difficult challenge (and perhaps not entirely germane to the work of conservation). In the case of the sub-category *Sense of Place*, however, it may be possible to speculate on the distinctions between values coded in South Africa and Nigeria. Both *Sense of Place* and its sub-sub-category, *Regional Identity*, were much more common in South Africa. *Sense of Place* values appeared in 56% of interviews in South Africa versus 19% in Nigeria, and *Regional Identity*, which was coded in 31% of interviews in the South African context, was not coded in any interviews in Nigeria. I offer two potential explanations for this.

First, the differing perceptions of *Sense of Place* may partly arise from interviewee demographics. Recall that most interviewees in South Africa were pensioners who had retired to Stilbaai; thus, it is possible that individuals who chose to stay in Stilbaai felt a stronger connection with the location (indeed, many interviewees did directly reference Stilbaai in *Sense of Place* value statements). Likewise, in Nigeria, common educational background may have influenced responses. Many interviewees conveyed the sense that their relationship with nature only began when they became associated with APLORI, which, if true, would likely lead to a more conceptual understanding of place than a feeling of personal connection. Indeed, the influence of educational background on values seems plausible, as interviewees in Nigeria broadly articulated more of an academic or convivial interest in their surroundings than place attachment, and vice versa in South Africa.

Secondly, differences may also be linked to *Heritage & Tradition* values. Recall that in South Africa, many interviewees described childhood ties to landscapes as a form of heritage, whilst most interviewees in Nigeria

described childhood nature experiences tied to values of *Knowledge, Care & Stewardship* or *Conviviality & Friendship*. This suggests that among Nigerian interviewees, attachment to entities was more important than to landscapes. The differing values observed corresponding with place experiences shed light on the problems of generalising between social-ecological systems. Though there is growing interest in the role of place attachment in supporting land stewardship (Lokocz et al. 2011; García-Martín et al. 2018; Gottwald & Stedman 2020; Trimbach et al. 2022), these results suggest that attachment functions differently in different contexts (e.g. Gurney et al. 2017; Murphy et al. 2019), and conservation practitioners may benefit from consulting community members to evaluate the type of attachment—i.e. to a specific landscape or to a conceptual place within a larger system—and designing interventions accordingly.

For citizen science participants, relational values of *Attachment to Places & Natural Entities* were not linked to motivation, but were abundant in interview responses. This again provides incentive for practitioners to inventory both participant relational values *and* motivations, because the prevalence of a value in a study population does not necessarily indicate its importance as a motivator.

Identity, Aesthetic & Inspiration, and Psychological & Therapeutic

Interviewee responses regarding identity and integration of self in nature spark questions regarding the relationships between citizen science participation, cultural background, educational background and nature-related identity. These questions may be explored through tools such as the Inclusion of Nature in Self scale (Martin & Czellar 2016) to quantify individual's senses of integration with nature in differing cultural contexts, and in relation to citizen science participation. Further study is also needed to determine the implications of nature integration for decision-making and conservation-oriented behaviour. *Aesthetic* values were prominent in all interview groups, and, timeously, the significance of beauty in human-nature interactions is beginning to emerge within conservation literature. In a study spanning nearly 15,000 individuals and 118 countries, Diessner & Niemiec (2023) found that among a suite of 23 character traits, appreciation of beauty was the strongest predictor of pro-environmental behaviour. A separate body of psychological research has explored the behavioural implications of awe, an emotion widely considered to incorporate appreciation of beauty (Keltner & Haidt 2003); positive experiences of awe with non-human nature have been linked to increased pro-environmental behaviour (Zhao et al. 2018; Wang et al. 2019; Feehly 2020). Richardson et al. (2020) include beauty as one of five “pathways to nature connectedness” which act as entry points for people into building human-nature relationships.

The same may also be true of citizen science; although participant motivations in this study were only weakly linked to *Aesthetic* relational values, the abundance of aesthetic values among *non*-participants may be of value to practitioners, as it indicates an accessible entry point for learning and recruitment. In interviews, several citizen science participants described how their initial curiosity began with noticing beauty—a colourful bird or attractive landscape—and deepened with the time and attention they dedicated to nature (i.e. Moon et al. 2024), whether through hiking or pursuing a degree in the natural sciences. The question of *why* beauty is not so important as *where* beauty leads; if noticing beauty in nature can draw people deeper into meaningful relationship with nature (e.g. Zylstra 2014), beauty may present an opportunity for citizen science practitioners

to engage with a wider audience and spark curiosity in a few. For instance, websites and social media platforms offer spaces to share beautiful photos, artwork, sound recordings, and words relating to nature with a virtually unlimited audience. However, the number of individuals who are reached by a post may not matter so much as the number of individuals who are *moved* by a post. How does beauty, experienced by a user in a digital format, mature into dedicated time and attention within nature? Further research is needed to understand the gap between appreciating beauty and choosing to follow it, as well as how relational values of knowledge and beauty interact and co-shape each other.

These questions and ongoing findings in the study of beauty, awe and human-nature relationships are the tip of a profound iceberg. Together, they demonstrate the prospective power of interdisciplinary collaboration between conservation biologists, environmental and behavioural psychologists, and social ecologists. Using knowledge and tools from multiple fields to characterise the relationships between aesthetic relational value, awe, perceptions of self, and conservation-oriented behaviour has the potential to transform contemporary understandings of how conservation works at the individual and community level.

Finally, considering the importance of *Psychological & Therapeutic* values across all interview groups in this study, it is encouraging to note that conservationists and psychologists alike have identified the healing capacity of human-nature relationships (Bratman et al. 2019; Ribeiro et al. 2021). Although *Psychological & Therapeutic* relational values were not linked to participant motivations in this study, participants and non-participants alike described the healing influences of nature in their lives. These findings are reflected in the health sciences, where medical professionals are beginning to leverage and even prescribe therapeutic experiences such as nature walks (Grassini 2022) as conservation and mental health management tools. More recently, health sciences research has argued specifically for the intrinsic health benefits of citizen science participation through exposure to natural environments (Williams et al. 2021; Pocock et al. 2023). Though this is a beginning, the literature still seems to fall short of realising the full scope of the human-nature relationship's psychological and therapeutic impact. One interviewee remarked that experiences with nature bring people closer to themselves; when asked what feeling accompanied their time spent in nature, another respondent simply answered, "joy."

Study limitations

A number of limitations were present in this study which may have influenced the interpretation of results.

Firstly, because interviews were organised and conducted remotely during the COVID-19 pandemic, interviewee recruitment rate was lower than the target figures. As a result, the variance in numbers of interviewees (16 in Nigeria versus 32 in South Africa) makes meaningful comparison between the two cultural contexts challenging. A follow-up study with a wider sample size would correct for this.

Secondly, the study could have benefitted from the inclusion of a third group of non-participants from the same region who were unaware of the citizen science project altogether. This would have created a gradient of value responses ranging from individuals very involved in citizen science to individuals very removed from citizen science, and may have provided useful perspective when interpreting differing responses from participants and non-participants.

Thirdly, there are potential challenges to consider in applying the relational values framework. As a developing concept, there is currently little understanding of its applicability in various settings. Although the framework allowed us to categorise a wide and rich variety of relational values, it is not comprehensive, and we may have omitted locally important values by not knowing to address them in interviews. In the future, this could be avoided through taking a period of observation or residency with each of the communities interviewed to build an understanding of local value idiosyncrasies.

Finally, there are limitations to relational values themselves. Perhaps the most apparent is that they do not necessarily capture the same richness in non-human nature as do intrinsic values; relational values are, by current understanding, limited to relationships between humans and non-human nature. This leaves ambiguity around the relationships linking non-humans to other non-humans, which, though perhaps unknowable, remain critical components of ecosystem flourishing. However, this may only be a limitation insofar as it is not acknowledged. If members of the scientific community will approach the concept of relational values with the caveat that the human perspective is inherently limited, it is made clear that there is no other perspective from which humans *can* relate to non-human nature (indeed, even attempts to consider another human being's lived experience are hollow replicas of the truth). Perhaps this is not a shortcoming, then, so much as a caution, and a consideration to hold in mind when engaging in discussions of relational values involving non-human entities and systems.

Relational values and implications for conservation-oriented behaviour

Though briefly explored through connections to action statements, the question of relational values and their relation to conservation-oriented behaviour is intentionally omitted from this study. The objective was to characterise the values surrounding two citizen science projects; understanding their implications for behaviour would require a different line of questioning, and ideally a long-term study design. Still, this is a burgeoning field, with growing evidence for the role of relational values as elicitors of action. In Australia, Pereira & Forster (2015) found a positive relationship between connectedness with nature (entangled with *Identity* values) and pro-environmental behaviour in undergraduate students. Studies from Reunion Island and China illuminate the role of *Sense of Place* values in likelihood to engage in conservation-oriented behaviour (Junot et al. 2018; Zhang et al. 2014, 2020). Research from Japan suggests that cultivating relational values in communities can promote actions which support a healthy social-ecological system (Uehara et al. 2019, 2020, 2022). A study in China found that relational values influenced attitudes, which in turn predicted pro-environmental behaviour (Ng & Cheung 2022). In Indonesia and Italy, biospheric values (closely linked with relational values of *Care & Stewardship*, e.g. Kleespies & Dierkes 2020) and values of environmental identity were strongly associated with pro-environmental behaviour (Tamar et al. 2020; Scopelliti et al. 2022).

As patterns linking behaviour and values emerge in the literature, understanding of the relevance of relational values to conservation grows. Though the connections are not explicitly explored here, the presence of multiple relational values among study participants in South Africa and Nigeria supports existing claims that these are important leverage points for conservation practitioners to understand, and presents a strong case for further research into the values-action relationship in both contexts. Action statements were broadly linked to values of

responsibility, care, and knowledge. Additionally, many action statements were social, indicating two or more individuals acting together, or one individual acting with another in mind. For citizen science, this may be a relevant link to explore further. As social relationships are already known to motivate participation in citizen science, which is itself a conservation-oriented behaviour, it is possible that these relationships are also capable of motivating other actions on nature's behalf. This could be investigated through interviews with a diverse sample of community members (citizen science participant and otherwise), asking targeted questions regarding conservation-oriented behaviours and who or what motivates these behaviours.

Cautionary note regarding observed differences

We observed some distinctions between cultural contexts in this study, and there may be a temptation to describe one context more favourably than another; for instance, to advocate the empathetic and integrated human-nature relationship observed in the Nigerian context over the more detached South African narrative. In this case, it is necessary to consider whether the observed distinction appears to make a difference to conservation-oriented behaviour, or if both ways of caring are equally effective. While transformation may in some cases be necessary, for conservationists, the focus should remain context-informed action: How can conservation interventions honour and reflect the cultures, languages, and values of local people to achieve a shared global objective (e.g. halting biodiversity loss)? Values are personally, socially and culturally entangled constructs, and when considered within their local contexts, they may act as deep leverage points for individual, interpersonal, and cultural transformation (e.g. Ives et al. 2020; Gray & Manuel-Navarrete 2021). The differences observed between groups in this study reiterate that proscribing a single set of practices across multiple contexts will be ineffective; however, it may be feasible to provide a framework of questions to guide practitioners towards better understanding the context they inhabit. An international and inclusive conservation must embrace walking many different paths to reach a common goal.

6. Conclusion

This study takes the first steps towards pursuing a values-inclusive conservation through citizen science by seeking to characterise the value profiles of ecological actors in two unique communities. Values can be considered a compass for identifying which aspects of the human-nature relationship are most important to an individual. Instrumental, intrinsic and relational values as a plural understanding lead to difficult and necessary questions surrounding where and how humans find meaning in non-human nature, and how these sources of meaning can inform an inclusive and action-oriented conservation. Though complex, values offer insights into which dimensions of the human-nature relationship conservationists and citizen science practitioners can invest energy into understanding and mobilising for better social-ecological and project outcomes. In this study, the fact that some broad patterns did emerge across spectrums of cultural, age, gender, socioeconomic, and personality differences is important: These data indicate that not all values are equal, and some (in this case relational values) carry greater relevance in the human-nature relationship than others. By evaluating the relational values present among individuals in a population and exploring their connections to motivation and action, conservationists and citizen science practitioners can invest into nurturing those values and incorporating them into governance. If relational values represent sources of meaning in an individual's perception of non-

human nature, then it is these sources of meaning which conservation must seek to protect, expand, and understand as pathways towards conserving the whole.

Table 1. Relational values framework utilised in coding, based on Riechers et al (2022b).

Primary category	Sub-category	Sub-sub-category
Identity	Individual	
	Social, Community & Collective	
	Cultural	
		Sovereignty
Heritage & tradition	Tangible Cultural	
	Tradition	
	Cultural Continuity	
		Social Memory
Social relationships	Social Cohesion	
		Sense of Belonging
		Sense of Community
	Social Relations	
		Social Bonds
Attachment to places & natural entities	Sense of Place	
		Regional Identity
	Kinship	
	Conviviality & Friendship	
Stewardship & responsibility	Care & Stewardship	
		Reciprocity
	Social Responsibility	
		Bequest
Knowledges	Indigenous & Local Knowledges	
		Shared Environmental Learning
	Environmental & Ecological Systems Knowledge	
		Personal Environmental Learning
Spiritual & religious	Spiritual Fulfilment	
	Sacred	
	Religious	
Aesthetic & inspiration	Aesthetic	
	Inspiration	
Psychological & therapeutic		

Table 2. Number of interviews containing relational, instrumental, and intrinsic value statements in South Africa and Nigeria, for citizen science (CS) participants and non-participants. Bold numbers indicate that the value type was coded in every interview in the category.

South Africa			Nigeria		Total/48 interviews
Value type	CS participant	Non-participant	CS participant	Non-participant	
Relational	17	15	8	8	48
Instrumental	2	11	7	6	26
Intrinsic	1	5	2	3	11

Table 3. Two-tailed Fisher exact test p-values for dominant relational value sub-categories and instrumental and intrinsic values. Asterisk (*) denotes a sub-sub-category; boldface text indicates a statistically significant result at $p < 0.05$.

Value	Sub(sub)-category	Fisher exact test p value	
		CS participant/non-participant	South Africa/Nigeria
Identity	Individual	1.000	1.000
	Social, community & collective	0.383	0.753
Heritage & tradition	Social memory	1.000	0.002
	Tradition	0.173	0.073
Social relationships	Social cohesion	0.098	0.074
	Social relations	0.383	0.005
Attachment to places & natural entities	Conviviality & friendship	0.727	0.712
	Kinship	0.117	0.746
	Sense of place	0.573	0.016
Stewardship & responsibility	Care & stewardship	0.487	0.064
	Reciprocity	1.000	0.042
	Social responsibility	1.000	0.764
Knowledges	Environmental & ecological systems knowledge	1.000	0.066
	*Personal environmental learning	0.511	0.499
	Indigenous & local knowledges	0.017	0.003
	*Shared environmental learning	0.383	<0.001
Spiritual & religious	Spiritual fulfilment	0.094	1.000
Aesthetic & inspiration	Aesthetic	0.318	0.004
	Inspiration	0.743	1.000
Psychological & therapeutic		1.000	1.000
Instrumental		0.011	0.013
Intrinsic		0.089	0.468

Table 4. Motivations expressed by citizen science participants in Nigeria and South Africa. Note that only the motivations in boldface text appeared in both countries.

Motivation	South Africa	Nigeria	Total
Social interactions/meeting like-minded people	5	3	8
Learning about nature/conservation	4	2	6
Collecting meaningful data	2	3	5
Enjoyment/fun	3	2	5
Local leadership	7	--	7
Raising conservation awareness/educating others	--	4	4
Way of keeping busy	3	--	3
Self-competition/'listing' species	3	--	3
Love of nature	2	--	2
Sense of responsibility towards nature	2	--	2
Visiting new places	1	--	1
Supporting other hobby (i.e. photography)	1	--	1

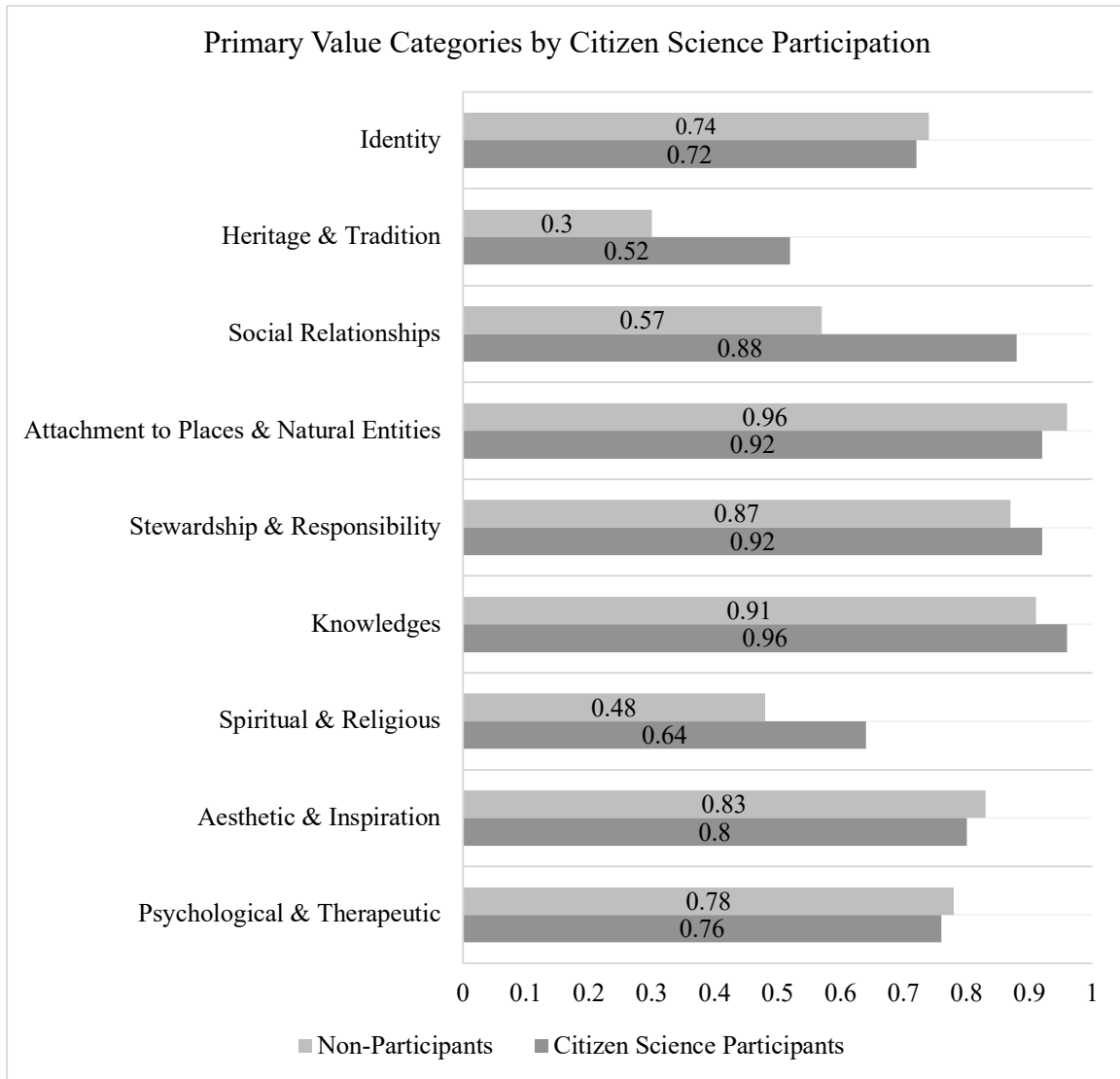


Figure 1. Frequency of relational value categories among citizen science participants and non-participants, where a value of 1 indicates that every interview in the group was assigned at least one code in that value category. Note the prominence of Knowledges, Stewardship & Responsibility, and Attachment to Places & Natural Entities for both groups.

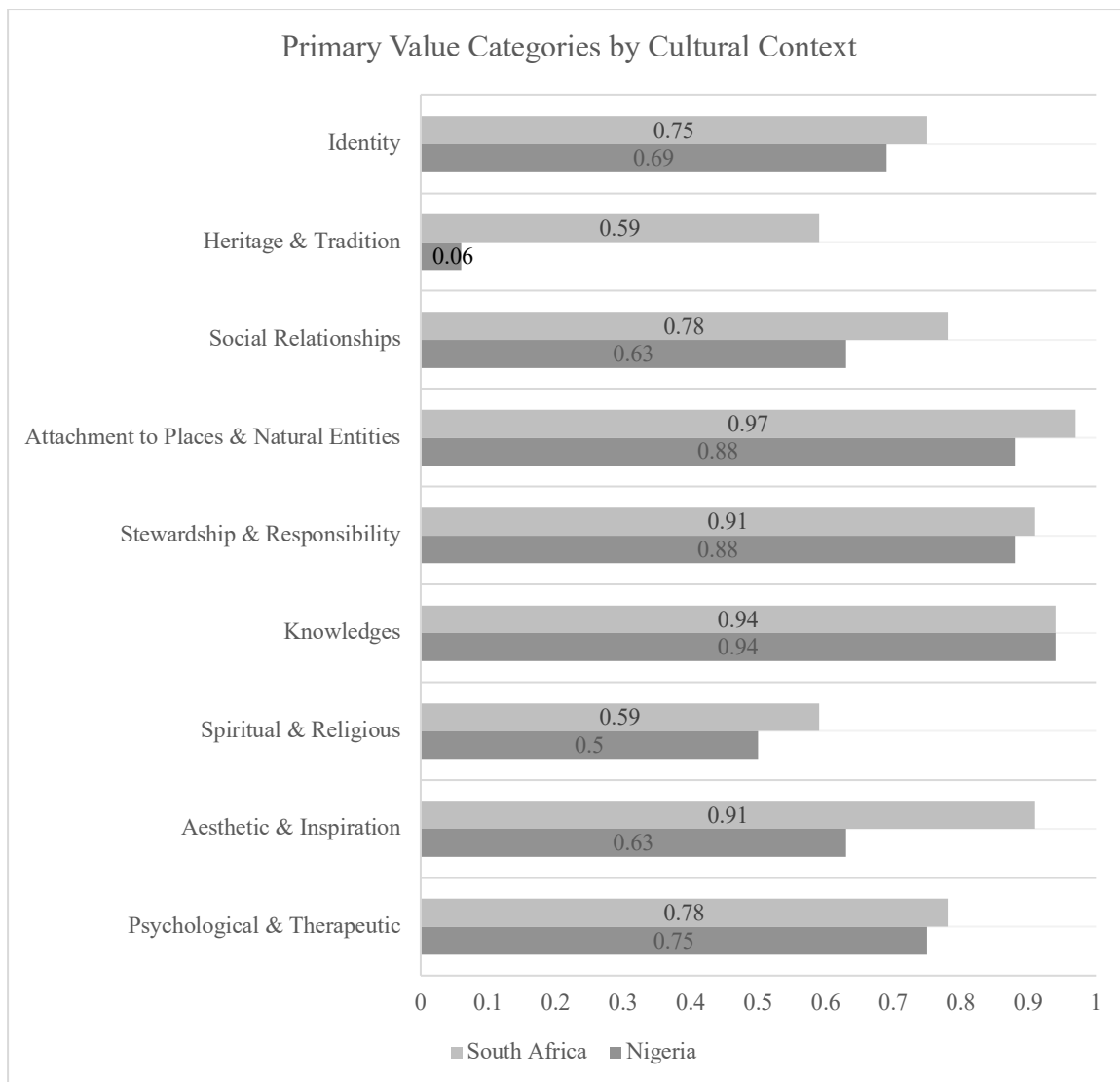


Figure 2. Frequency of relational value categories among interviewees in South Africa and Nigeria, where a value of 1 indicates that every interview in the group was assigned at least one code in that value category. Note the similarities between cultural contexts, with the exception of the value category “Heritage & Tradition,” which was more prominent in the South African context.

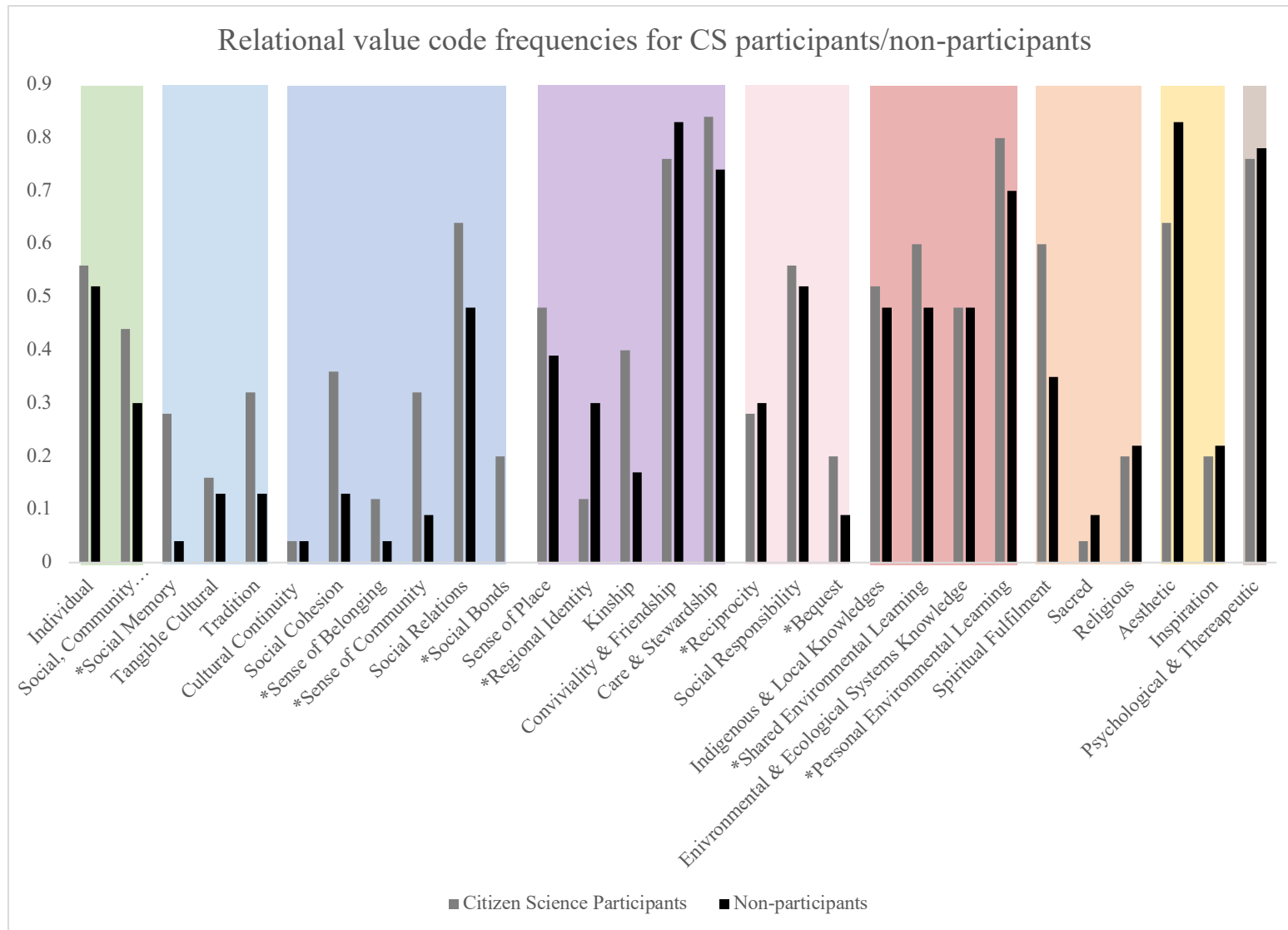


Figure 3. Frequency of relational value sub-categories and sub-sub-categories among citizen science participants and non-participants, where a value of 1 indicates that every interview in the group was assigned at least one code in that value category.

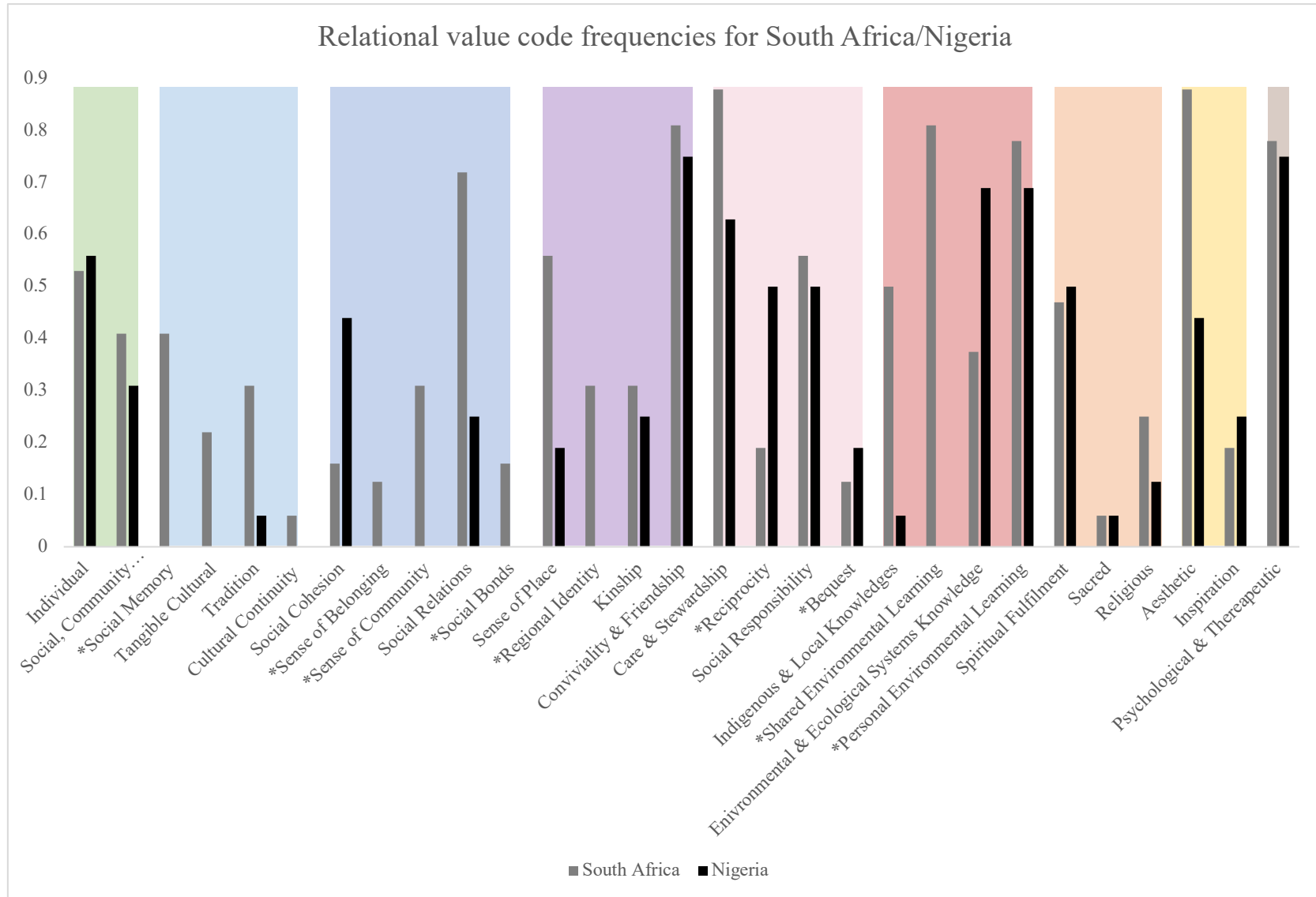


Figure 4. Frequency of relational value sub-categories and sub-sub-categories among interviewees in South Africa and Nigeria, where a value of 1 indicates that every interview in the group was assigned at least one code in that value category.

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CONCLUSION



There is grace in complexity, in actions cohering, in sum totals.

Suzanne Simard

'Finding the Mother Tree'

At the beginning of this thesis, I set out to investigate the contributions of African Bird Atlas Projects to three primary challenges facing contemporary conservation: Monitoring biodiversity, democratising participation in research, and crafting inclusive interventions alongside the people inhabiting ecosystems. Through an exploration of the data collected by atlasers in Hessequa, South Africa (Chapter 3), I demonstrated the ability of citizen scientists to generate nuanced and up-to-date avian distribution data for a region. The case study in Hessequa represents an African Bird Atlas Project ably meeting the first of the three challenges to conservation: collecting the quantity and quality of data necessary for biodiversity monitoring. This conclusion was strengthened in Chapter 4, where the data collected by atlasers was successfully applied to create a local monitoring scheme for detecting species declines. The creation of the monitoring scheme also addressed the role of an African Bird Atlas Project in democratising participation in research, the second conservation challenge. The scheme is built on data collected by citizen science participants and is designed to feed directly back into conversations between participants and local and scientific leadership to prioritise future monitoring efforts. Though not yet trialled in full, the Hessequa monitoring scheme presents an example of one way to democratise participation by involving citizen science participants in project co-creation, data analysis and decision-making. Lastly, in Chapter 5, I explored potential tools for African Bird Atlas Project practitioners to apply in crafting inclusive interventions (the third conservation challenge) by assessing the values of participants and their relationships to motivation. This chapter reveals the importance of relational values not only in participant motivations, but in human-nature relationships broadly, and paves the way for future research into the links between relational values, motivation, and behaviour.

There is still much work to be done. Although African Bird Atlas Projects in this study were capable of meeting two pressing conservation challenges and making progress toward a third, these remain examples and possibilities. Further research is needed within the individual atlas projects of different countries to determine, for example, the feasibility and logistics of implementing a community monitoring scheme, or to characterise the values and motivations of local citizen science participants. There is also a need to further the work begun in this thesis by testing ways to incorporate participant values and motivations into project design, and, more broadly, to include values in local conservation interventions.

Still, the pages of this document evidence the powerful potential of African Bird Atlas Projects to support transformative and meaningful citizen science and conservation in continental Africa. These initiatives and others like them perpetuate the natural science's ongoing transition from preservation to conservation. Consider the etymology of those words, *preserve*, from the Latin *prae* + *servare*, to keep safe, and *conserve*, from the Latin *com* + *servare*, to keep together, and recall the reflection from the introduction to this thesis: *Terminology is an echo of reality, and, in many ways, science is an iterative practice of naming what is already true.* The conceptual movement from 'keeping safe' to 'keeping together' is embedded within the term *conservation*, and the goals of the discipline are beginning to reflect this. Monitoring biodiversity, democratising participation in research and working alongside people within ecosystems to craft inclusive interventions—these are pathways

towards *conserving*, towards *keeping together*. And as citizen science, like the ecosystem concept, continues to evolve, it grows as a formidable force binding humans and non-human nature in the work of being alive and together.

APPENDICES



It is only when people care about and are vested in one another that they advocate together, that they move together in the same direction, recognising that a solution to someone's problem—even if it's not my problem—is a solution that we all need, because we are one people, and we are united.

Dr. Vivek Murthy

Appendix A

Interview protocol & interviewee demographics

Interview Protocol

	Question
1	<i>Can you tell me about your history with nature? (i.e., where did your relationship with nature start?)</i>
2	<i>How do you spend time in nature?</i>
3	<i>What feeling(s) accompany your time in nature?</i>
4	<i>What do you appreciate about nature?</i>
5	<i>If you close your eyes and picture it, how do you see the relationship between yourself and nature?</i>
6	<i>Do you perceive any problems or challenges to nature?</i> <i>Follow up: What do you think can be done? What do you think other people think of this issue?</i>
7	<i>What motivates you to participate in citizen science?</i>

Basic interviewee demographics

	Nigeria		South Africa	
	<i>Male</i>	<i>Female</i>	<i>Male</i>	<i>Female</i>
Citizen science participants	5	3	11	6
Non- participants	5	3	9	6

Appendix B

Additional topical references by chapter

Chapter 1

Interdependence

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ONWARD



Yo creo que hay mucho por hacer.

There is so much we can do.

Francia Márquez