AUTHORS:
Nicky Allsopp[1]
Jasper A. Slingsby[1,2]
Karen J. Esler[3]

AFFILIATIONS:
[1]South African Environmental Observation Network (SAEON) Fynbos Node, Cape Town, South Africa
[2]Centre for Statistics in Ecology, Environment and Conservation, Department of Biological Sciences, University of Cape Town, Cape Town, South Africa
[3]Centre for Invasion Biology, Department of Conservation Ecology and Entomology, Stellenbosch University, Stellenbosch, South Africa

CORRESPONDENCE TO:
Nicky Allsopp

EMAIL:
allsopp@saeon.ac.za

DATES:
Received: 20 Dec. 2018
Revised: 11 Mar. 2019
Accepted: 30 May 2019
Published: 26 Sep. 2019

HOW TO CITE:
Allsopp N, Slingsby JA, Esler KJ. Identifying research questions for the conservation of the Cape Floristic Region. S Afr J Sci. 2019;115(9/10), Art. #5889, 8 pages. https://doi.org/10.17159/sajs.2019/5889

ARTICLE INCLUDES:
☒ Peer review
☐ Supplementary material

DATA AVAILABILITY:
☒ Open data set
☐ All data included
☐ On request from author(s)
☐ Not available
☐ Not applicable

EDITOR:
John Butler-Adam

KEYWORDS:
Fynbos biome, environmental sustainability, Mediterranean-type ecosystem, IPBES Conceptual Framework

FUNDING:
None

Identifying research questions for the conservation of the Cape Floristic Region

We conducted a survey among people working in the nature conservation community in an implementation, research or policy capacity to identify research questions that they felt were important for ensuring the conservation of the Cape Floristic Region. Following an inductive process, 361 submitted questions were narrowed to 34 questions in seven themes: (1) effective conservation management; (2) detecting and understanding change: monitoring, indicators and thresholds; (3) improving governance and action for effective conservation; (4) making the case that biodiversity supports critical ecosystem services; (5) making biodiversity a shared concern; (6) securing sustainable funding for biodiversity conservation; and (7) prioritising research. The final questions were evaluated against the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Conceptual Framework to test whether the questions addressed elements identified by this Framework as those essential to ensure that conservation contributes to a positive future for the Cape Floristic Region. We found that all elements in this Framework received attention from the collective group of questions. This finding suggests that the conservation community we approached recognises implicitly that research in multiple disciplines as well as interdisciplinary approaches are required to address societal, governance and biological issues in a changing environment in order to secure the conservation of the Cape Floristic Region. Because the majority of people responding to this survey had a background in the natural sciences, a challenge to tackling some of the questions lies in developing integrative approaches that will accommodate different disciplines and their epistemologies.

Significance:

- We present a hierarchical compendium of research questions to generate the knowledge required to conserve the Cape Floristic Region as a social-ecological system.
- The conservation community of the Cape Floristic Region collectively recognises that effective conservation management needs to be supported by knowledge of ecosystems, factors that impact them and context appropriate conservation approaches. In addition, knowledge to develop effective governance and institutions, sustainable funding and broader societal participation in conservation are also identified.
- The questions reflect the elements and linkages of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Conceptual Framework, suggesting that the questions presented follow global prerogatives for developing a sustainable future.
- The range and complexity of knowledge gaps presented suggest the need for a broader research agenda that includes the social sciences and humanities to address conservation in the Cape Floristic Region.

Introduction

Globally, initiatives such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Sustainable Development Goals (SDGs) emphasise the need for wise management of the natural environment, because its decline will impact human well-being and ultimately our future on this planet. Similarly, the World Economic Forum has increasingly highlighted environmental risks as threatening ecosystem services.[1] Environmental pressures with global or local impact are threatening systems such as the Cape Floristic Region (CFR), a globally unique biodiversity hotspot and conservation priority.[2] Effective conservation of natural systems and countering of anthropogenic drivers of change that threaten the environment, biodiversity and ecosystem services requires guidance from well-grounded research. Conservation research, in turn, needs to be prioritised by stakeholders more broadly than the research community alone.[3]

Several features set the CFR apart from other globally important conservation areas. The dominant vegetation is a shrubland, generally on low nutrient soils, in a winter rainfall regime, with 68% of the over 9000 plant species present endemic to this region.[4] Stochastic fire cycles drive many processes from evolution to biotic interactions.[5] Hence, many environmental mitigation schemes promulgated at global levels (e.g. the Bonn Challenge's forest-themed restoration) may be unsuitable in this unique ecosystem.

In this study, which formed part of a larger study to identify research priorities for global Mediterranean-type ecosystems[26], we adapted the approach of Sutherland et al.[3,6] by canvassing widely in relevant communities for their research priorities for conservation. Although ours is not the first attempt to collate conservation research priorities in the CFR, it differs from Steyn et al.'s[7] in that it was not developed as a funding strategy for biophysical conservation research nor as an expert review of research directions.[8]

We present a summary of the conservation research questions provided by the community of practitioners and scholars in public and private sectors in the CFR and evaluate their research questions within local and global contexts.

The questions address conservation of biodiversity, which is recognised as underpinning many of the SDGs directly or indirectly. We wanted to know whether the questions related to the CFR are reflective of the kind of knowledge required by current global initiatives, such as the SDGs, to ensure an environmentally sustainable and societally equitable future, by assessing how many elements and linkages these questions addressed in the IPBES Conceptual Framework for connecting people and nature.[9]

Methods

This project formed part of an initiative of researchers from the five Mediterranean-type ecosystems, associated with the Society for Conservation Biology Europe Section and the International Society of Mediterranean Ecologists, to identify the 100 priority questions that, if answered, would have a high probability of increasing the success of actions targeted at the conservation of biological diversity in the five Mediterranean-type ecosystems of the world.[26]

Identifying stakeholders and soliciting questions

Following ethical clearance from Stellenbosch University for working with human subjects (SU-HDS-000323), the questionnaire (Data set 1)[10], in the form of an online Google Form, was distributed by email to people associated with conservation in the CFR through implementation or research. Each recipient was asked to provide up to 10 questions which, if answered, would, in their opinion, have a high probability of increasing the success of actions targeted at the conservation of biological diversity in the CFR. We did not explicitly request, nor prohibit, the sharing of the email, so some respondents may have been additional to our distribution list (see below). Respondents submitted their questions anonymously online, and responded to additional questions aimed to solicit a profile of educational, work and sector characteristics of respondents (Data set 2[10]). Respondents received at least one reminder by email.

The broader CFR conservation community is small and well networked.[11] We selected potential respondents on the basis of key sectors in conservation and key people within these sectors or organisations (decision-makers, public and private conservation practitioners, and researchers working at government policy, conservation or research agencies, non-governmental organisations, consultancies and universities). Generally, these were people that we knew personally, had met at meetings, who held relevant positions in key organisations, or who had attended the annual Fynbos Forum (a conservation research, practice and policy conference) in the last five years. Our biases were towards people who had worked in conservation-related fields (i.e. not students). We had difficulty identifying people in the business world associated with conservation (e.g. those involved in environmental responsibility programmes) and recognise this as a gap.

Processing responses

While respondents were asked to assign their questions to predetermined categories for the global project (a deductive approach), we chose to derive the summary questions for the CFR following an inductive approach, clustering the submitted questions until generalised themes emerged.

All three authors jointly reduced the original 361 questions (362 after splitting compound questions and eliminating submissions that could not be turned into questions)(Data set 3)[10] to 34 summarised questions and clustered these into seven themes. We then revisited the original questions and extracted more specific questions (126) which added further context to the summarised questions.

We chose this approach over that taken by Sutherland et al.[3,6] because we felt that it captured the array of questions and topics posed by respondents more fully than an elimination of questions to select 100 original questions favoured by a committee.

We concede that there are opportunities for bias in whichever approach is taken, but in our approach with fewer original questions to manage, it was possible to better preserve the intentions of the original questions. Our approach also allowed us to include the essence of poorly articulated questions on an equal footing to grammatically well-constructed and scientifically nuanced questions, as we wanted to provide a platform for a broad cross-section of active participants in different spheres of conservation irrespective of their written English fluency. We were also able to explore poorly constructed questions which yielded yes/no type answers for their underlying research requirements.

We assessed the conservation scope of the questions to provide an additional verification that the clustering process correctly emphasised general themes and topics of the submitted questions in terms of what aspects of conservation they addressed. This was done by counting how many times words (or the core of words e.g. implement or implementation) or terms appeared in the submitted questions. These terms were clustered into topics (Data set 4).[10]

Finallly, we assessed each of the final 34 questions against the IPBES Framework[9] to see which elements and linkages of the IPBES Framework it addressed. For example, for the question 'How effective are restoration interventions in restoring biodiversity and ecosystem function?', restoration is seen as falling into the element 'Direct drivers' that, if successful, will influence 'Nature' which in turn affects processes that influence 'Nature's benefits to people'. We scored how many times the elements and linkages were addressed by the 34 summary questions.

Results

Respondent profile

We sent the questionnaire to 176 people (114 men, 62 women) and 53 (30%) responded (26 men, 23 women and 4 undisclosed)(Data set 2).[10] Respondents provided, on average, 6.8 questions each for a total of 361 individual questions. Of those who responded, 17 were employed in research, 16 in government conservation entities, 10 in environmental non-governmental organisations, 7 were consultants, and the balance of 3 were in other employment. From the original pool of solicited people, researchers were less likely to respond (24% responded) than people in government conservation entities, environmental non-governmental organisations or consultants (average response rate 35%). The average age of respondents was 45 years (range 29–63 years), average years of experience in broad conservation was 16.8 years (range 1–39 years) and average length of employment in their current capacity was 9.4 years (range 2 months to 35 years). In terms of qualifications, 22 held doctoral degrees, 19 master's, 5 honours, 1 bachelor's, and 2 post-school diplomas (4 were undisclosed). The majority of respondents had studied the biological (n=24) or conservation (n=13) or environmental (n=5) sciences. Among this group, eight were from other disciplines: two each from the humanities and education, while horticulture, agriculture, business management and energy studies had single representatives and three did not disclose their studies.

Conservation perspectives were evenly distributed across plants, animals and society; the scale most focused on was landscape or ecosystem (Figure 1).

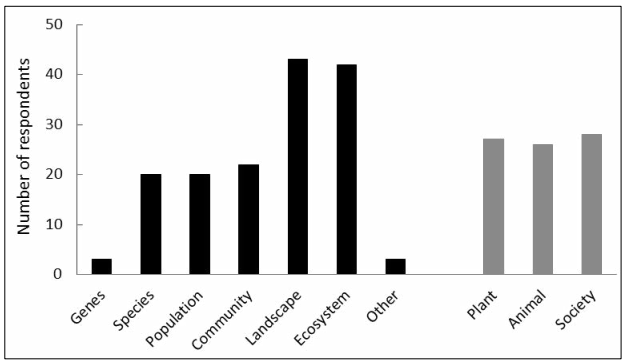

Figure 1: Respondents were asked at what ecological scale (black bars) they focused their efforts and whether this focus was predominantly on plants, animals or society (grey bars). Respondents (n=53) could choose more than one focus area in each category.

The synthesised questions

We developed a hierarchical classification of the 34 summary questions under seven themes (Table 1). Further elaboration of the themes and derived questions was provided by 126 sub-questions. This structure provides a means of directing people to the area of their interest and a more accessible way of presenting research questions, thus allowing readers to more readily identify their areas of interest and proceed from the more general to the specific depending on their objectives.

Table 1: Research questions were arrived at through an inductive analysis of 361 questions submitted by members of the broader Cape Floristic Region (CFR) conservation community (Data set 3[10]). Main questions are organised under themes and further clarification is provided in the right-hand column where relevant. The number of original questions from respondents contributing to a theme or research question is indicated in brackets.

Theme A: Effective conservation management (143 original questions)	
A1. What fundamental knowledge of CFR evolution (speciation, phylogeny, diversification, endemism) and ecology (life-history traits, biotic and abiotic interactions and processes driving community assemblages) do we still need for effective conservation planning and management? (21 original questions)	Can vegetation types serve as surrogates of other biota for conservation planning? What knowledge of breeding systems, dispersal, recruitment and other critical life-history traits, influence of soils and interactions along ecotones, do we need for effective conservation? What additional taxonomic knowledge and understanding of phylogenetics do we need for effective conservation?
A2. How effective is the current conservation estate for protecting biodiversity into the future? (7 original questions)	What are indicators of effective conservation inclusive of all landscape elements, freshwater systems and terrestrial? Are all components adequately mapped to determine their conservation status? How effective is the conservation estate at conserving all components of biodiversity?
A3. To what extent are conservation management objectives such as ecosystem service or biodiversity conservation being achieved outside formal protected areas? (6 original questions)	What levels of conservation are being achieved on formal and informal private protected areas, under stewardship agreements, and on land not under conservation management?
A4. How do we prioritise ecosystems for conservation management or restoration? (7 original questions)	
A5. What approaches to landscape planning and management can be developed that will enable us to optimise and sustain ecosystem services and biodiversity in transformed and production landscapes in a changing world? (35 original questions)	What are the impacts of various (established and emerging) land uses on biodiversity and ecosystem services? How do we avoid harmful impacts of infrastructure development? How can we optimise infrastructure developments for biodiversity e.g. power lines, rail and road reserves as biodiversity corridors? What green (engineered) infrastructure approaches can be incorporated? How do we manage agricultural systems for more ecologically sustainable outcomes? How can we integrate mixed use landscapes for better conservation? How effective are land sparing versus land sharing approaches? How can urban planning contribute to ecological sustainability?
A6. How effective are restoration interventions in restoring biodiversity and ecosystem function? (7 original questions)	What restoration methods work for farm lands? How do we restore abiotic components? How do we restore following invasive species? Are there innovative technologies for restoration? What degradation processes are irreversible? When is partial restoration acceptable?
A7. What spatial configurations are most effective for conservation? (6 original questions)	How effective are corridors (including agriculture, restored lands, riparian zones) and buffers around sensitive systems, among other spatial configurations? What spatial surrogates for evolutionary processes actually maintain and sustain these processes?
A8. What are the thresholds beyond which fragmented or otherwise impacted ecosystems become dysfunctional in maintaining biodiversity and ecosystem services? (12 original questions)	What is the carrying capacity of wildlife on land units? How effective at conservation are fragments with respect to altered fire regime (exclusion or escalation)? Are there minimum areas below which extinction debt is accrued? What is the genetic integrity on fragments? Are tops of mountains facing similar issues to fragments?
A9. How can the design and management of current protected areas be optimised to anticipate and adapt to likely range shifts in plant and animal species due to climate change? (3 original questions)	How do we mitigate or avoid future losses with current planning and management?
A10. How do we develop a nuanced and responsive approach to integrated invasive species management in a changing world? (22 original questions)	What biocontrol options exist for all invasive species, and for which different stages of the life cycle? How do we detect emerging weeds and prevent their establishment? How do we integrate all levels of policy and management in approaches? How do we ensure effective and sustainable approaches?
A11. How do we manage fire in a responsive manner in a changing world? (10 original questions)	What are different optimal fire return intervals for different vegetation units? What are the thresholds of potential concern for vegetation fires in terms of return interval and spatial cover? What role can fire play in restoration, especially integrated into alien plant clearing? How does one manage wildfire at the urban interface?
A12. Are there effective ex-situ approaches to species conservation outside their natural habitat? (7 original questions)	Is assisted migration a feasible option? What are the implications for gene pools? Is seed banking an option? How effective is search and rescue?

Table 1: Continued.

Theme B: Detecting and understanding change: Monitoring, indicators and thresholds (87 original questions)	
B1. How do global change drivers impact biodiversity, from species to ecosystem function, including across boundaries? (33 original questions)	What is the impact of a range of drivers (colonialism, loss of herbivores and predators, urbanisation, agriculture, fragmentation, mining, commercial bees, wild harvesting, tourism, recreational activities, invasive species, N_2-fixing invasive species, water abstraction from rivers and aquifers, CO_2 and climate change) on biodiversity? What emerging impacts arise from interactions between CO_2 and climate change and other drivers of change? What components of biodiversity are resilient to global change? Which ones are susceptible to climate change? Does groundwater buffer surface water temperatures? What can we learn from the impacts of global change on biodiversity across Mediterranean-type ecosystems?
B2. How is global change affecting ecosystem processes? (17 original questions)	How are ecosystem processes such as fire regime (intensity and frequency), fog precipitation, species interactions and aquatic processes being affected by global change?
B3. What impacts does global change have on ecosystem services and livelihoods dependent on biodiversity and what adaptation or mitigation will be required? (4 original questions)	How can humans adapt to reduced natural resources and ecosystem services impacted by climate change? What have we learnt from past extreme events (e.g. floods and droughts) that will aid us to understand and manage future impacts?
B4. What are the critical interactions and thresholds for (irreversible) biodiversity change? (13 original questions)	What indicators are robust for detecting thresholds of potential concern or vulnerability timeously for remedial action to be implemented? Which species show common responses to climate change? What are the climate thresholds for recruitment, growth, survival, reproduction, and pollinator and predation interactions? What elements are resilient to change?
B5. How do we best monitor for biodiversity conservation in a variable and changing world? (17 original questions)	How do we determine baselines in highly specious systems which are spatially and temporally variable and subject to stochastic disturbance events? Are current vegetation maps and vegetation units good enough for monitoring? How do we determine which elements are essential for ecological assessment (wetlands, rivers, animals etc.)? How do we deal with special communities (e.g. seeps with locally endemic species) nested in vegetation units? What interactions between units (e.g. feedbacks between marine and terrestrial systems) may be critical to these systems and need assessment?
B6. How do we determine sustainable guidelines for harvesting or consumptive use of indigenous species? (3 original questions)	What levels of harvesting of wild resources are sustainable? Are there life-history traits that can indicate suitability for harvesting? What are knock-on effects of harvesting? What alternatives to wild harvesting would work?
Theme C: Improving governance and action for effective conservation (48 original questions)	
C1. What institutional and governance structures are most effective at conserving biodiversity? (3 original questions)	What institutional arrangements promote sustainable development across all sectors?
C2. How can legislation and policy become more effective in conserving biodiversity? (12 original questions)	Is existing environmental legislation effective? How can prosecution under environmental acts become more effective? Can regulatory processes be simplified while improving effectiveness? How does environmental legislation affect behaviour? How can environmental impact assessments become more effective in guiding sustainable development and reducing biodiversity loss (beyond species of special concern)? How can environmental legislation be devolved to the most relevant and effective level?
C3. In a developing world context and in an environment of limited resources, how are ecosystem-based concerns best integrated into environmental decision-making? (8 original questions)	What strategies are effective in bringing environmental concerns into planning and development? What developments impact negatively on environmental sustainability? What compromises and trade-offs are acceptable in conservation in the face of poverty and inequity? What developments negatively affect nature-based livelihoods?
C4. What biodiversity research outputs do we need to influence conservation management and decision-making at different scales and across different sectors? (22 original questions)	How best can biodiversity concerns be mainstreamed in municipal Spatial Development Frameworks and other planning tools? What tools best support conservation objectives in planning? What mechanisms would support the effective translation of scientific knowledge for management and decision-making? How do we communicate climate change science for effective and efficient conservation management and decision-making at different scales and across different sectors? How can climate change research be made scale effective?
C5. How do we translate international conservation strategies for implementation at the local level? (2 original questions)	

Table 1: Continued.

Theme D: Making the case that biodiversity supports critical ecosystem services (19 original questions)	
D1. What is the evidence base for links between healthy biodiversity and ecosystem services? (7 original questions)	What impact do invasive species (both plants and animals) have on ecosystem services? What biodiversity-friendly practices would improve ecosystem service delivery? Do restored ecosystems deliver ecosystem services effectively? What is the value of biodiversity-based ecosystem services?
D2. How does biodiversity contribute to human well-being? (2 original questions)	What role does nature play in the mental, physical, emotional, social and spiritual well-being of citizens?
D3. What aspects of biodiversity support ecosystem function and resilience? (5 original questions)	Do CFR species offer redundancy that supports resilience? Can we increase the resilience of systems? What role do mammals play in supporting resilience?
D4. How do we communicate the evidence base for links between healthy biodiversity and ecosystem services effectively to society, managers and decision-makers? (5 original questions)	How is biodiversity information incorporated into non-biological curricula/disciplines? What are government officials' levels of understanding of ecosystem services? How can we convince communities and governments to invest in ecosystem services? Who should take up messaging around biodiversity and ecosystem services? How can scientists communicate better? How can knowledge be effectively communicated to conservation managers?
Theme E: Making biodiversity a shared concern (44 original questions)	
E1. How can we accommodate different world views to provide motivation for conservation? (14 original questions)	How do people's world view, value systems and generational differences influence their acceptance of conservation messages? Which values, perceptions or world views act as barriers to conservation behaviour? What is the potential for heritage protection (e.g. archaeological sites, cultural heritage) to complement biodiversity conservation?
E2. How do we obtain people's support and action for biodiversity conservation? (20 original questions)	How can people be supported to become more environmentally aware? How do we develop local ecological literacy at schools and in society? What has worked in breaking down barriers to biodiversity-friendly behaviour? How can conservationists change their messaging to be more effective with other groups e.g. business? What aspects or actions by the biodiversity sector alienate the general public and decision-makers? How can science best be translated to make biodiversity messages accepted? Does the use of flagship species work in promoting biodiversity behaviour? Can we take advantage of natural disasters for public engagement on environmental issues? How can individual citizens best be motivated to take responsibility for environmental concerns in their realm of interest? What knowledge tools that promote conservation can support decision-making by society around everyday aspects of their lives? What roles can ordinary citizens play to enhance biodiversity conservation? How can we expand the areas in which people can get involved in conservation action? How can citizen science be expanded?
E3. What incentives and enablers can be used to promote conservation behaviour among different sectors of society? (10 original questions)	What influences people's conservation behaviour? What regulatory regimes are effective in influencing conservation behaviour? What enablers or incentives ensure that people, including land managers, take ownership of conservation action on land? What disincentivises conservation behaviour?
Theme F: Securing sustainable funding for biodiversity conservation (21 original questions)	
F1. How do we promote investment in ecosystem services in a sustainable way? (9 original questions)	How do we build public support for funding restoration and protection of ecosystem service? How much will mismanagement of ecosystem services cost? How do we assess the contribution of biodiversity to ecosystem services? How do we make the case for future savings through current investment in ecosystem services?
F2. What effective mechanisms can be used to fund conservation organisations? (8 original questions)	How can we counter approaches that require self-funding of conservation: e.g. ecotourism as the sole funder of conservation? What are the best public–private partnership models to attract investment in conservation? What additional value-adding skills can private sector stakeholders provide? What skills and resources would improve financial management of conservation? What impact will global change have on current revenue gaining activities e.g. ecotourism?
F3. How can we improve the benefits to livelihoods of investments in protected areas and biodiversity conservation? (4 original questions)	How can using a social ecological systems thinking approach in conservation bring better benefits to people? How can conservation be achieved with other land-use options? How can the conservation and livelihood outcomes of public conservation orientated poverty-relief programmes be improved?
Theme G: Prioritising research (1 original question)	
G1. How do we effectively communicate conservation research needs to ensure they are taken up by researchers? (1 original question)	

The scope covered

An assessment of the words used by respondents in their questions shows a strong focus on the environment, its characterisation, properties and the processes that regulate them (Table 2, Data set 4).[10]

Words associated with conservation action were also frequently mentioned. Primarily, the interest was focused on vegetation, with freshwater systems also predominant. The dominance of vegetation as the focus of conservation effort by the group submitting questions is emphasised by the fact that terms associated with various types of fauna were only mentioned 38 times, while terms associated with vegetation types were recorded 210 times. However, the focus was not exclusively on biodiversity as terms associated with the human dimension and covering social, economic or governance aspects were mentioned 354 times (Table 2). Terms associated with tracking change and monitoring impact of interventions (monitoring and assessment in Table 2) were mentioned 139 times. Direct drivers of change were mentioned predominantly in the context of land use (both urban and agricultural), followed by invasive species and climate change.

Table 2: Clustering of terms used in respondents' submitted questions (see Data set 4)[10]

Topics	Number of times terms associated with topics are mentioned
Biodiversity conservation	
Ecosystem properties and processes	756
Conservation action	488
Vegetation	210
Monitoring and assessment	139
Freshwater systems	77
Animals	38
Soil systems	27
Marine	3
Human dimensions	
People, their conservation values and behaviour	142
Economic considerations	125
Governance considerations	87
Drivers of change	
Land use	135
Invasive species	48
Climate change	39

Meeting current global environmental challenges

An assessment of how reflective the 34 CFR conservation research questions (Table 1) are of the elements and pathways in the IPBES Conceptual Framework is depicted in Figure 2. There are strong emphases on how direct drivers affect nature; how nature provides benefits to people and how this affects quality of life. Many questions also emphasised the role of institutions and governance.

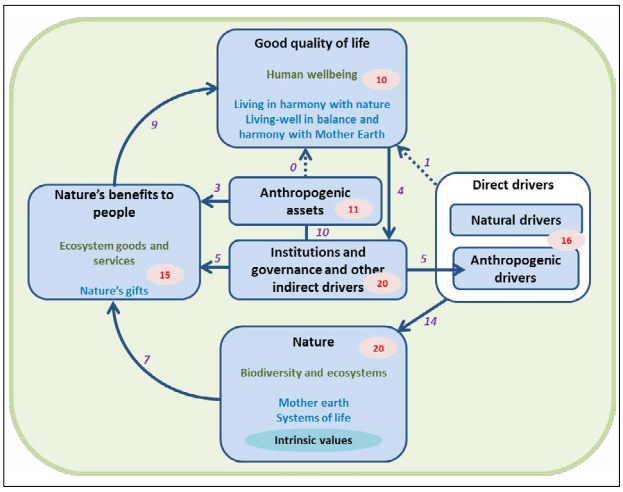

Figure 2: A depiction of how the Cape Floristic Region conservation questions address the core elements and linkages of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Conceptual Framework. Red numbers indicate the number of questions addressing an element and the purple italic numbers indicate the number of questions addressing the linkages. One question may address more than one element or linkage. The IPBES Framework is redrawn from Diaz et al.[9] where further explanations of the elements and linkages are described.

Discussion

We are fortunate to have documentation of early efforts to prioritise conservation research in the CFR.[8,12] The first on formal record was concerned with diminishing streamflow in the 1930s.[13] In response, the Jonkershoek Small Catchment Experiments were established to understand the effect of fynbos versus plantation pines on water delivery.[13] In the current study, questions associated with the management of freshwater systems and control of invasive alien species remain high priorities.

In 1945, Wicht and other prominent biologists under the auspices of the Royal Society of South Africa investigated the causes of the 'degradation' of Cape vegetation.[12] Enduring themes from that period and that remain of concern today are fire management, catchment hydrology, invasive alien species and land-use conversion. Issues that have receded as conservation priorities are grazing management and soil erosion.[14] However, an emerging concern is the impact of stocking natural areas with wild herbivores, many extralimital. Conservation for the sake of providing recreational and educational opportunities for city dwellers was touched on in the Wicht report,[12] but the need for research on these topics and on urban ecology is more recent. Governance, institutional arrangements and interactions between wider society and conservation practitioners are more urgent in the current era, reflecting the nexus between conservation and the broader society that informs the SDGs and IPBES.

A further assessment of research needs and funding priorities for the CFR identified six themes.[7] Steyn et al.'s[7] first theme (Discovering and understanding the Cape Floristic Region's biodiversity) is similar to A1 in the current study (Table 1) but their subsequent topics (Ecosystem health and services, Fragmentation, Climate change, Alien Invasives, and Freshwater systems) speak more narrowly to specialist biodiversity researchers than to implementers of research findings. We consider land use as a driver of change more broadly, and issues around social, governance and conservation management which emerged strongly in our study as requiring research in their own right, are dealt with by Steyn et al.[7] as communicating with and influencing people under each theme but are not elaborated on as research topics.

While questions around fundamental biodiversity knowledge (A1) and impacts of global change on biodiversity (B1) are dominant, most of the other questions in our Themes A and B focus on research to inform the

design, management and monitoring of conservation measures. Over a third of all the questions (Themes C–F) deal with developing knowledge around topics which do not focus directly on biodiversity, including governance, promoting conservation through ecosystem services, communicating and eliciting conservation action from broader society and how to fund biodiversity conservation sustainably. A 2014 synthesis of CFR research suggested a focus predominantly on biodiversity components.[5] While in respect of invasive alien species, South African research is largely focused on ecological processes and impacts, with social and applied research under-represented.[15]

The use of words and terms in our respondents' questions suggests independently that the derived questions reflected the intentions of the original questions. Vocabulary focused on understanding ecosystems and transferring this knowledge into conservation action, while recognising that governance, institutions and wider society are important elements. One lone, but somewhat relevant question in Theme G, is how researchers might be encouraged to pursue conservation relevant research. This question is pertinent because the majority of questions we solicited came from people working broadly in conservation implementation and not from researchers. Thus the research agenda is driven mainly by conservation practitioners and policymakers. Moreover, many of the questions require research in the social sciences and humanities and these groups were poorly represented among our respondents. The challenge of integrating social sciences and humanities effectively in conservation research, and not merely delegating them to service provision roles, is well recognised.[16-18]

There is general congruence between Sutherland et al's.[3] global questions and our CFR questions, although 23 of the global questions were not addressed for the CFR (e.g. marine systems, polar ice or permafrost, and sea level rise). In contrast, while gaps in fundamental ecological knowledge are explicitly addressed by CFR participants, Sutherland et al. mention this only in their preamble[3] to their Ecosystem Management and Restoration section.

The shrublands of the CFR have the highest number of threatened ecosystems[19] and the highest density of taxa of conservation concern in South Africa[20]. Soils are of very low organic content and wildfire regularly destroys above-ground biomass as an intrinsic process that sustains fynbos; so this system is unlikely to support ecosystem-based carbon capture projects to mitigate climate change. This highlights the need for locally relevant approaches to manage biodiversity in shrublands even when they run counter to the global focus on forestation as a mechanism for capturing carbon. Global conservation topics that are also not germane to the CFR are nanotechnology, GMOs and climate change associated animal vectors.

In contrast to the global questions,[3] the CFR questions more frequently dealt with the nuances of governance and human values, perceptions and behaviour associated with conservation (and how these can be influenced). These are probably best addressed at the local level and reflect heightened awareness for research on these topics as a consequence of initiatives such as the Cape Action Plan for People and the Environment (C.A.P.E.).[21] The IPBES Conceptual Framework[9] also strongly emphasises the interlinkages between these components, suggesting the local questions reflect concerns that are globally recognised as important for biodiversity conservation.

Historically, concern by the public for conservation in the CFR was vested in resources such as game and wildflowers that wealthy or propertied people wanted to protect from the competing demands made by poor people for livelihood support.[22] In the modern era, understanding the social context of conservation, and of using conservation to provide pathways out of poverty is pronounced. While acknowledging the interdependence between people and the environment, as reflected in the IPBES Conceptual Framework,[9] some questions also addressed how development prerogatives for poverty alleviation could be met while ensuring a sustainable future. Similar questions have been raised around the SDGs.[23]

The capacity of the current questions to populate most of the elements and major linkages of the IPBES Conceptual Framework[9] suggests that our respondents are well aware that ensuring conservation of the CFR requires knowledge that includes people and their institutions as well as biodiversity. The alignment of the questions with the IPBES Conceptual Framework suggests that a large sector of the general conservation community in the CFR regard conservation in the context of global sustainability and connectedness to society, mirroring the role that conservation can play in attaining the SDGs. Despite this, the original questions overwhelmingly reflect a positivist approach of delivering evidence based on natural science methods of research, not surprising given the background of the majority of respondents in this study.

The CFR questions reflect that an interdisciplinary and intersectoral approach is called for that addresses dynamic social-ecological systems changing through time as a consequence of global and local pressures. The concept that biodiversity conservation is about pristine areas is also eroding with matters being raised around urban and production landscapes.

Our results are unlikely to be affected by low survey response rates or non-response bias. Sheehan[24] showed a decline in response rates to email solicited surveys from rates over 50% in the early days of email to an average response of 33% for the period 1996–2000. In this context, and given that there is a negative relationship between response rates and long surveys such as ours,[25] we consider our response rate of 30% (53 respondents) to be high. Variation in response rates by occupation was low, and researchers, who showed a slightly lower response rate, still made up the largest respondent group. We feel that our online approach made our survey accessible to a broader range of respondents from different sectors and the anonymity of respondents facilitated submissions on a broader range of topics than alternatives like workshopping.

We conclude that the questions provided by the conservation sector in the CFR show a willingness on the part of this community to work towards conservation in a societal context that will support, for example, the SDGs. However, we recognise that inclusion of multiple disciplinary and societal perspectives is missing from this analysis. Such a broadening of perspectives is likely to change the nature of the questions presented here as plurality of knowledge is brought to bear on this broadly natural science approach to conservation knowledge generation.[16-19]

Acknowledgements

This work was carried out in the scope of the 'Priority questions for Mediterranean biodiversity conservation' initiative, promoted by the Society for Conservation Biology and the International Society of Mediterranean Ecologists. We thank the leaders of this project, Francisco Moreira and Pedro Beja, and the research team for providing a stimulating environment in which to conduct this research. We are grateful to the anonymous respondents who contributed their priority research questions, reflective of careful thought and considerable time investment.

Authors' contributions

This project emerged from a project proposed by Francisco Moreira and Pedro Beja, University of Porto, to a global group of Mediterranean-type ecosystem scientists at a Society of Conservation Biology meeting attended by K.J.E. who invited J.A.S. and N.A. to make up the South African team. Henceforth, all the authors worked as equal partners in developing the project approach based on the international team's proposal, developing an online questionnaire and inviting respondents. K.J.E. obtained ethical clearance from Stellenbosch University. All authors worked together to inductively reduce the submitted questions to a shorter list of priority questions presented in this manuscript. Individually, the authors worked on co-agreed aspects of the analysis of submitted questions that overlapped with the global project and which informed our analyses but are not necessarily presented in this paper. N.A. wrote the first draft of the paper. All authors participated in further revisions. N.A., with advice from K.J.E. and J.A.S., prepared the data for archiving.

References

1. World Economic Forum (WEF). The global risks report 2018. 14th ed. Geneva: WEF; 2019. Available from: http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf

2. Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GAB, Kent J. Biodiversity hotspots for conservation priorities. Nature. 2000;430:853–858. https://doi.org/10.1038/35002501

3. Sutherland WJ, Adams, WM, Aronson RB, Aveling R, Blackburn TM, Broad S, et al. One hundred questions of importance to the conservation of global biological diversity. Conserv Biol. 2009;23:557–567. http://dx.doi.org/10.1111/j.1523-173 9.2009.01212.x

4. Manning J, Goldblatt P. Plants of the Greater Cape Floristic Region 1. The Core Cape flora. Strelitzia. 2012;29:1–853.

5. Allsopp N, Colville JF, Verboom GA, editors. Fynbos: Ecology, evolution, and conservation of a megadiverse region. Oxford: Oxford University Press; 2014. https://doi.org/10.1093/acprof:oso/9780199679584.001.0001

6. Sutherland WJ, Armstrong-Brown S, Armsworth PR, Brereton T, Brickland J, Campbell CD, et al. The identification of one hundred ecological questions of high policy relevance in the UK. J Appl Ecol. 2006;43:617–627. https://doi.org/10.1111/j.1365-2664.2006.01188.x

7. Steyn L, Wilson T, Kirkwood D, Krug C. Research strategy and funding priorities for the Cape Floristic Region [document on the Internet]. In: Data conservation research priorities for the Cape Floristic Region [data set]. c2007 [cited 2019 Mar 11]. Available from: https://doi.org/10.6084/m9.figshare.7484903

8. Van Wilgen BW, Carruthers J, Cowling RM, Esler KJ, Forsyth AT, Gaertner M, et al. Ecological research and conservation management in the Cape Floristic Region between 1945 and 2015: History, current understanding and future challenges. Trans Roy Soc S Afr. 2016;71(3):207–303. http://dx.doi.org/10.1080/0035919X.2016.1225607

9. Diaz S, Sebsebe D, Carabuas J, Joly C, Lonsdale M, Ash N, et al. IPBES Conceptual Framework – connecting nature and people. Curr Opin Env Sust. 2015;14:1–16. https://doi.org/10.1016/j.cosust.2014.11.002

10. Allsopp N, Slingsby JA, Esler KJ. Data conservation research priorities for the Cape Floristic Region [data set]. In: figshare. https://doi.org/10.6084/m9.figshare.7484903

11. Gelderblom C, Wood J. The Fynbos Forum, its impacts and history [webpage on the Internet]. c2018 [cited 2019 Mar 11]. Available from: https://fynbosforum.org.za/index.php/documents-archive/home-page/200-the-fynbos-forum-its-impacts-and-history/file

12. Wicht CL. Report of the Committee on the Preservation of the Vegetation of the South Western Cape. Cape Town: Royal Society of South Africa; 1945.

13. Bennett BM, Kruger FJ. Ecology, forestry and the debate over exotic trees in South Africa. J Hist Geogr. 2013;42:100–109. https://doi.org/10.1016/j.jhg.2013.06.004

14. Raimondo D, Von Staden L, Foden W, Victor JE, Helme NA, Turner RC, et al. editors. Red list of South African plants. Strelitzia. 2009;25:1–668.

15. Abrahams B, Sitas N, Esler KJ. Exploring integrative research in the context of invasive alien plant management. S Afr J Sci. 2019;115(3/4), Art. #4263, 11 pages. https://doi.org/10.17159/sajs.2019/4263

16. Dunkley R, Baker S, Constant N, Sanderson-Bellamy A. Enabling the IPBES conceptual framework to work across knowledge boundaries. Int Environ Agreements. 2018;6:779–799. https://doi.org/10.1007/s10784-018-9415-z

17. Fish R, Church A, Winter M. Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. Ecosyst Serv. 2016;21:208–217. http://dx.doi.org/10.1016/j.ecoser.2016.09.002

18. Vadrot ABM, Rankovic A, Lapeyre R, Aubert P-M, Laurans Y. Why are social sciences and humanities needed in the works of IPBES? A systematic review of the literature. Innovation. 2018;31(suppl1):S78–S100. https://doi.org/10.1080/13511610.2018.1443799

19. RSA. National list of ecosystems that are threatened and in need of protection. National Environmental Management: Biodiversity Act (Act 10 of 2004). Government Gazette. 2011;34809. Available from: http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/10/20111209-National-Gazette-No-34809-of-09-December-2011-Volume-558.pdf

20. SANBI. Statistics: Red list of South African plants [database on the Internet]. Version 2017.1 [cited 2018 Nov 30]. Available from: http://redlist.sanbi.org/stats.php

21. Ashwell A, Sandwith T, Barnett M, Parker A, Wisani F. Fynbos Fynmense: People making biodiversity work. SANBI Biodiversity Series 4. Pretoria: South African Biodiversity Institute; 2006. Available from: https://www.sanbi.org/wp-content/uploads/2018/03/biodiversityseries4.pdf

22. Van Sittert L. Making the Cape Floral Kingdom: The discovery and defence of indigenous flora at the Cape ca.1890–1939. Landsc Res. 2003;28:113–129. https://doi.org/10.1080/01426390306529

23. International Council for Science (ICSU), International Social Science Council (ISSC). Review of the Sustainable Development Goals: The science perspective. Paris: ICSU; 2015. Available from: https://council.science/publications/review-of-targets-for-the-sustainable-development-goals-the-science-perspective-2015

24. Sheehan KB. E-mail survey response rates: A review. J Comput Mediat Commun. 2001;6(2). https://doi.org/10.1111/j.1083-6101.2001.tb00117.x

25. Fan W, Yan Z. Factors affecting response rates of the web survey: A systematic review. Comput Human Behav. 2010;26:132–139. https://doi.org/10.1016/j.chb.2009.10.015

26. Moreira F, Allsopp N, Esler KJ, Wardell-Johnson G, Ancillotto L, Arianoutso M, et al. Priority questions for biodiversity conservation in the Mediterranean biome: Heterogeneous perspectives across continents and stakeholders. Conserv Sci Pract. 2019; e118, 11 pages. https://doi.org/10.1111/csp2.118