

JUST EARTH OBSERVATION FOR CONSERVATION (JEO4C)

JEO4C will provide the first international comparative analysis of how Earth Observation can produce social (in)justice in conservation landscapes. The project will deliver the conceptual advances, empirical evidence, and practical strategies needed to ensure that Earth Observation data facilitate equitable and effective responses to the global biodiversity crisis.

THE RESEARCH CHALLENGE

Advances in Earth Observation (EO) are transforming how we understand and respond to the global biodiversity crisis, but are also creating urgent social justice challenges for people living in conserved lands. EO data, derived from technologies such as satellites and drones, are increasingly integral to the design and management of conservation actions, including global goals laid in the 2022 Kunming-Montreal Global Biodiversity framework¹. But the social impacts of the 'technological turn'² in conservation are poorly understood – a troubling oversight given that conservation actions impact millions of lives³. Most importantly, we lack the conceptual approaches and empirical evidence needed to link lived experiences of (in)justice in conserved lands to the ways that EO data are generated, analysed, and used, both within and outside conservation landscapes. This makes it extremely challenging to identify approaches that leverage EO to address rather than reproduce the social justice issues associated with conservation, such as violations of the rights of local peoples. **JEO4C will develop a new way of conceptualising the relationships between EO, conservation, and justice, and, in doing so, produce the empirical and practical advances needed to deliver a step change in how EO data are used and governed in conservation.**

The prevailing discourse around EO in conservation hails its potential to support delivery of environmental benefits – reflecting the broader contention that 'sustainable development will falter without data'⁴. But this techno-optimistic discourse obscures the ways that **use of EO threatens to exacerbate existing and enact new social harms in conserved lands**. Drones are being used as part of conservation surveillance⁵, including in places where suspected poachers are shot on sight. Microsatellite arrays developed by commercial entities (e.g., Planet) are mapping conserved lands to centimetre-scale resolutions, with few safeguards against the harms this non-consensual visibility could bring to marginalised peoples. Inequalities in who can use EO data risk shifting decision-making away from conservation landscapes, such as when spatial prioritisation strategies are developed by academics thousands of miles away^{6,7}. Moreover, EO data may create a false sense of certainty, with uncertainties and biases downplayed, overlooked, or deliberately obscured in ways that reproduce or entrench unjust conservation practices. Addressing these issues is a key priority for conservation practitioners, donors, and many local peoples. For example, PI Pritchard and Co-I Sauls were recently approached by the United Nations Environment Program World Conservation Monitoring Centre to co-develop a process for exploring the justice benefits and risks of the World Database on Protected Areas. Major players in the global EO community (including NASA and the Group on Earth Observations) have recently made calls for ethical data use and for using data to advance social justice^{8,9}. Indigenous and local peoples have raised concerns over data sovereignty and sought to deploy EO in ways which work for rather than against their interests¹⁰.

Achieving just use of EO in conservation requires improved evidence about how and why advances in monitoring, and surveillance capabilities affect social justice outcomes for people. That conservation should be socially just is crucial from both a moral perspective and an instrumental one – conservation interventions are less likely to be successful if they are perceived as inequitable¹¹. Yet our recent review¹² found only 31 papers containing any substantive consideration of justice or ethics in relation to conservation EO (out of >16,000 papers on EO for conservation and environmental management). These 31 papers were skewed towards drones over satellite data, and towards single-site, local-scale case studies, limiting the potential to develop theories and policies that work across different contexts, and leaving obscure the broader political economy of conservation EO. This highlights **an urgent need to develop a much richer understanding of how EO data (in)justices are produced and experienced in different contexts, in order to achieve more just 'datascape' informed by the values of those living in conserved lands.** These advances are also urgently needed in data justice research beyond

conservation¹³, which is only just beginning to grapple with how to respond to the justice issues arising from the 'panoptic' gaze of EO.¹⁴

OUR RESEARCH QUESTIONS AND GOALS

JEO4C will transform knowledge about the justice benefits and risks of increased use of EO data and technologies in conservation. As an action-oriented project, JEO4C will work with actors developing, using, and impacted by EO data to understand and reform data-driven conservation practice, thereby enabling just and effective responses to the biodiversity crisis. Our work program will bridge presently disconnected bodies of research in the social, natural, and data sciences, using a comparative case study analysis and the notion of the 'datascape' to interpret how the structures and decisions shaping use of EO coalesce to produce lived experiences of (in)justice in conservation landscapes. This will provide the platform from which we will co-develop alternative visions for just EO datascape and the strategies by which these can be created, in partnership with those generating, using, and impacted by data,

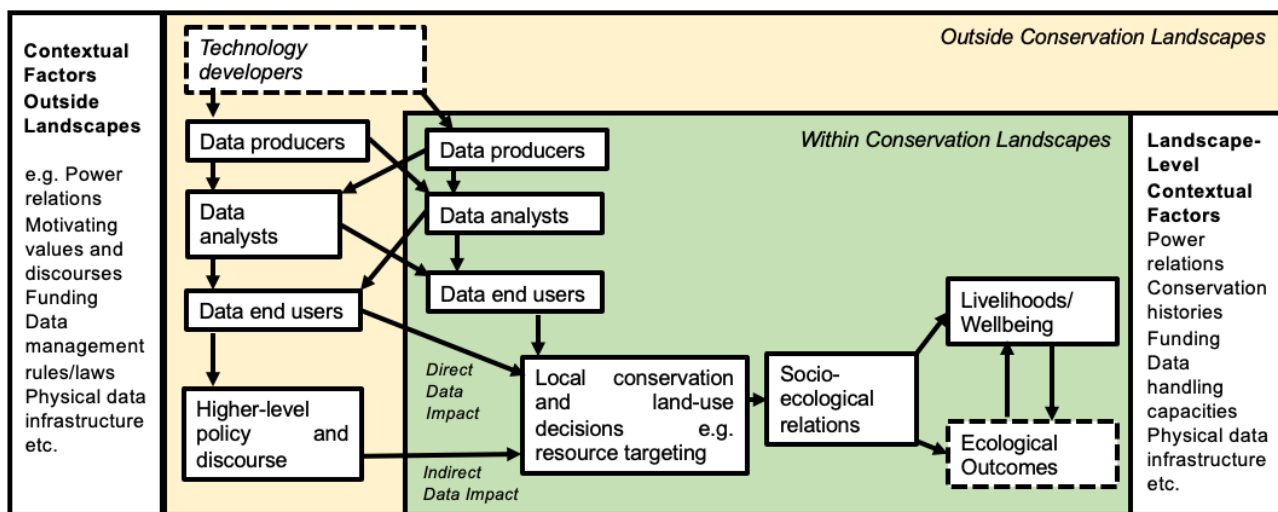


Figure 1 Schematic of the 'datascape', which draws from recent work on environmental data infrastructures¹⁵ and frames conservation landscapes as situated within international networks of data producers, analysts, and users. EO data consequences within landscapes arise from structures and decisions both within and outside landscapes which shape the nature and use of EO data. Dotted lines are aspects of the datascape which will not be addressed in this project.

JEO4C will address four overarching research questions:

RQ1: What are the structures of the EO datascape associated with different conservation landscapes – who produces, analyses, and uses data, in what ways, and why do different datascape structures emerge in different places?

RQ2: What are the lived consequences of current datascape structures in conservation landscapes and in what ways are these perceived as (un)just by different actors?

RQ3: How do residents of conservation landscapes and other conservation actors envisage more just EO datascape, and do these visions reflect different notions of justice?

RQ4: What interventions in how EO data are generated, analysed, governed, and used can mitigate risks of injustice and advance data practices which enable socially just conservation?

JEO4C will make several key additions to research on conservation remote sensing and the wider literature data on data justice. **First**, we will link work on data justice^{13,15} to research on plural notions of justice in conservation^{16,17}, thereby developing an approach to conceptualising data justice that reflects the needs and priorities of local peoples. **Second**, we will radically expand understanding of EO and justice in conservation by comparing multiple sites across Global North and South and by identifying how choices far beyond study landscapes can produce lived experiences of (in)justice. **Third**, we will innovate by building EO data justice frameworks and strategies in partnership with those peoples most impacted by conservation actions. The understanding and outputs we develop through our project have the potential to mitigate data injustices and advance data practices which benefit millions of residents of conserved lands around the world.

The knowledge, solutions, and partnerships that our project will develop are especially timely given the billions of pounds of current and planned investment in EO technologies and techniques to address the global biodiversity crisis. For example, NASA's Landsat Next mission – which will provide the biggest leap in public EO environmental monitoring capacity in decades – has an expected cost of over US \$1 billion¹⁸. Philanthropic funds such as the Bezos Earth Fund have put EO data at the heart of commitments to spend US\$10 billion by 2030 to protect nature and support climate change adaptation¹⁹. EO is also central to the design and implementation of private sector initiatives such as carbon markets, which are expected to value \$200 billion/year by 2050 and strongly impact governance choices in conservation landscapes²⁰. JEO4C will help to ensure that these immense investments deliver changes in conservation policy and practice that address rather than exacerbate issues of social justice. In doing so, JEO4C will also directly address the key ESRC research priority areas of 'Net Zero, Environment, Biodiversity and Climate Change' and 'Digital Society', as well as UKRI goal to catalyse multi- and inter-disciplinary solutions to global challenges.

OUR APPROACH

Our approach is organised into three phases (Fig 2): **revealing**, **reimagining**, and **transforming** conservation EO dataspace. We will analyse the dataspace associated with four case study sites where EO is increasingly important in conservation governance: the Maya Biosphere Reserve (Guatemala), the Peak District National Park (UK), Albufera Natural Park (Spain) and the Mount Kenya Ecosystem (Kenya). By framing these landscapes as embedded within larger-scale EO architectures, we will gain unique insights into how factors inside and outside landscapes coalesce to produce different experiences of EO-data-driven conservation (in)justice.

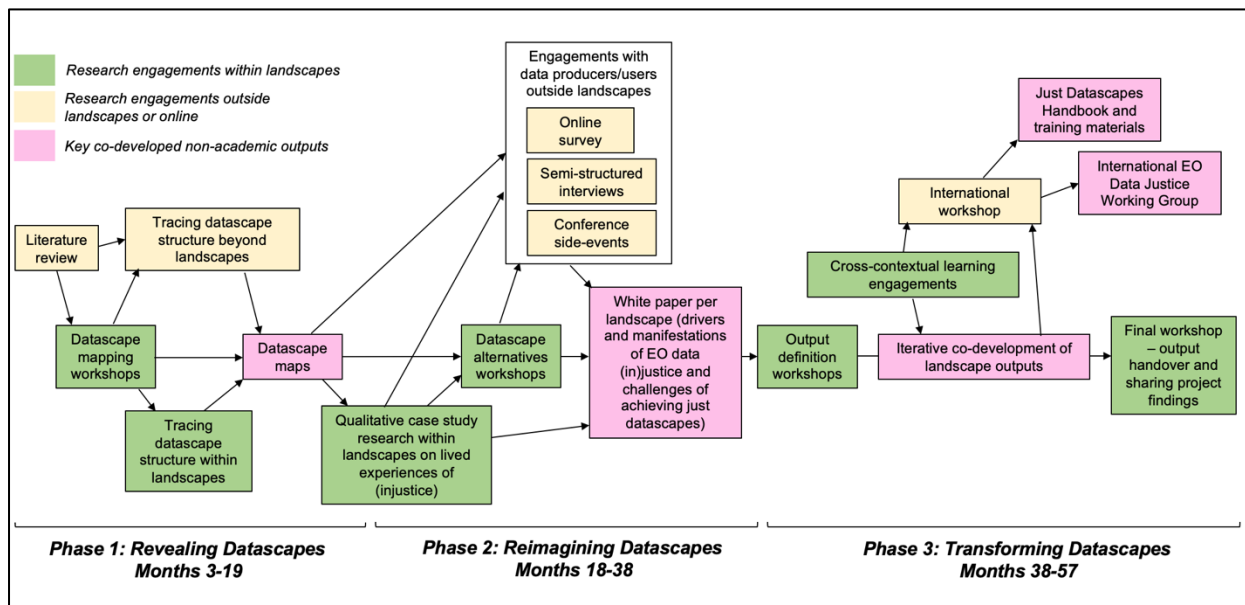


Figure 2 The JEO4C co-development approach, organised into the three phases of revealing, reimagining, and transforming dataspace. A full breakdown of tasks, timings, and outputs is provided under Project Management.

Our methodology is a multi-disciplinary blend of approaches from political ecology, earth observation, critical data studies, and co-development research. At the centre of our approach is a series of parallel workshops held in each of the four study landscapes and involving actors working with or impacted by EO technologies and data. Holding four workshops in each landscape over the five years of the project will allow us to convene and develop working groups in each study landscape involving actors using and impacted by EO, and the repeat engagements with these groups will allow us to build the trust and capacities needed to deliver our project goals. We will combine these workshops with literature-based research, semi-structured interviews, participant observation, cross-site comparison and learning, and iterative co-development of our pathways to impact. This approach will allow us to understand the actors, relationships, and choices shaping current experiences of data (in)justice, and to envision and implement strategies that advance justice in conservation EO in our study areas and in conservation landscapes around the world.

A case study approach will allow us to understand: (i) how (in)justice arising from EO use is perceived and experienced by those living in conserved areas; (ii) how particularities of place arising from different landscape histories, such as governance systems, social conflicts, technological capacities, and ecological characteristics can produce different patterns and perceptions of EO data (in)justice; and (iii) how patterns of (in)justice are shaped and determined by factors and decisions within global EO data ecosystems and supply chains outside of conservation landscapes themselves. Existing research in this area has largely either analysed EO data and information products and highlighted *potentials* for injustice²¹ or focused on local-scale technology use and impacts (usually of drones²², despite the radical capabilities of new satellite technologies). We will make a unique contribution by bridging these two approaches, adopting a holistic view that spans from data generation all the way to lived consequences. A key innovation of JEO4C will be to analyse case study landscapes within their larger-scale networks of data relations, through which we will explore how lived (in)justice within landscapes is influenced by choices made within wider globalised EO dataspheres and supply chains. As such, the impact of our project will extend beyond our direct case study landscapes by identifying changes in wider EO dataspheres and practices that will influence conservation EO globally.

OUR CASE STUDY LANDSCAPES

The case study sites in this project are four institutionally complex, mixed-use conservation landscapes (Table 1), where there is substantial and growing use of EO in decision-making. These sites have been purposively selected because they have shared sets of contestations, including around management of water, land tenure rights, and the trade-offs between agriculture, conservation, and livelihood values of landscapes. But they also have important ecological and socio-political differences which will impact how EO data is used within landscapes, how these landscapes are influenced by global-scale EO data architectures, and the resulting conservation (in)justices experienced by landscape residents. The inclusion of sites in both Global North and South will be particularly instructive, given that North-South comparisons are rarely drawn in research on conservation technologies or data justice. The mix of commonalities and contrasts will facilitate cross-contextual learning and comparative analysis, allowing us to develop understandings which will have relevance in a much wider range of contexts (see WP4 for details of up-scaling methods).

Table 1 Key characteristics of the four case study landscapes. **While we have wider networks of collaborations in each site, we list only partners who have already provided letters of support agreeing to participate in JEO4C's co-development process.*

Site	Landscape Characteristics	Main Uses of Earth Observation	Research Partners*
Peak District National Park, UK	Upland national park near to several major urban centres; managed by the Peak District National Park Authority through collaboration with farmers, local councils, NGOs, and private sector companies.	Prioritising and monitoring conservation and restoration efforts; evaluating compliance of with subsidy schemes and land management regulations; monitoring park access	Peak District National Park Authority Moors for the Future
Maya Biosphere Reserve, Guatemala	Tropical forest region and UNESCO biosphere reserve; includes sites administered by the National Council for Protected Areas as well as community-based forestry concessions and areas governed by private companies, local governments, and NGOs.	Used for monitoring, surveillance and planning purposes, including forest fire prevention; users include government actors, large-scale conservation NGOs, and local peoples.	Association of Forest Communities of Péten (ACOFOP) The Nature Conservancy
Mount Kenya Ecosystem, Kenya	Area surrounding the Mount Kenya National Park, including mountainous and lowland habitats, several forest reserves, community-managed forests, and private wildlife conservancies	Monitoring trends in biodiversity, land use, and land productivity; gathering intelligence to support anti-poaching efforts	Indigenous Movement for Peace Advancement and Conflict Transformation (IMPACT)
Albufera Natural Park, Spain	Wetland ecosystem that is an important habitat for migratory birds bordered by agricultural land and city of Valencia; managed by the Albufera National Park Authority through collaboration with farmers, government, and NGOs.	Monitoring and managing water levels and quality; monitoring habitats and protected species; surveillance and regulation of agriculture in surrounding areas and upstream Júcar river basin	Albufera Natural Parc Authority Unió de L'auradors Xúquer Viu Per l'horta

Our research in these case study sites will also benefit from our long-standing working relationships with knowledgeable and well-connected in-landscape partners (Table 1). Partners who have committed to supporting JEO4C's work to reveal, reimagine, and transform EO datascares, including playing an active role in stakeholder engagement and co-production activities, local management agencies (Peak District National Park Authority in the UK; Albufera Natural Parc Authority in Spain), international conservation organisations (The Nature Conservancy in Guatemala), local NGOs and collaborations engaged in ecosystem conservation and social justice (Moors for the Future in the UK; Xúquer Viu and Per l'horta in Spain), community organisations (ACOFOP in Guatemala; IMPACT in Kenya), and agricultural cooperatives (Unió de Llauredors). The co-development process we envisage is achievable because of this existing groundwork of trust and collaboration with these and broader organisations in our study sites, and because the goals of our partners are well-aligned with the objectives laid out in this proposal as set out in letters of support included with our proposal.

JEO4C RESEARCH WORK PACKAGES

JEO4C is organised into four research WPs and a fifth WP focused on project management.

WORK PACKAGE 1: REVEALING EO DATASCAPES (months 3-19, co-ordinated by Enns and Foster) will conceptualise and map the structure of the datascares associated with each of the four study landscapes and develop new evidence about why different datascares emerge in different places (RQ1).

Using the framework of the datascape (Fig 1), we will begin with a **scoping exercise (M3-7)**, reviewing academic and grey literatures to develop an overview of which EO data are being used, by whom, and in what ways. This includes both EO data users within study landscapes, and the larger networks of data producers, analysts, and users beyond the geographic boundaries of our study landscapes. We will then convene a **datascape mapping workshop (M8-M11)** in each landscape involving key actors resident in or local to case study landscapes identified through the scoping review. These workshops will expand our mappings of the actors, datasets, and decisions comprising each of the four study datascares. Following this workshop, we will use a data journeys approach²³ to **continue tracing the movements of EO data through data supply chains (M12-16)** from production to use and impacts. Through a mixture of in-person and online semi-structured interviews, we will also enhance our understanding of the contextual factors shaping the choices made with and about EO data. The literature reviews, workshops, and semi-structured interviews will be brought together to produce a **datascape map for each study landscape**, which will form the basis for the dialogues in WP2. As well as publishing one case study paper documenting the datascape structure for each of the four landscapes, we will also use **narrative synthesis (M16-19)**²⁴ to carry out a comparative analysis of findings from the four study sites and examine the factors which have produced current datascape structures.

WORK PACKAGE 2: REIMAGINING EO DATASCAPES (months 18-38, co-ordinated by Sauls and Reguena Mora) will enhance understanding of how EO use produces (in)justice in conserved lands (RQ2) and explore how different notions of justice lead to different visions for more just EO datascares (RQ3). We will advance the recent theorisation by members of the research team around conservation data justice¹⁵ by recognising that there are plural notions of justice that determine whether conservation actions are perceived as fair and equitable by different actors¹⁶. Recognising plurality avoids assumptions that impose standardised conceptions of justice on rural peoples who may have different values and aspirations. This recognition will also allow us to draw out synergies and tensions between different notions of justice held by different actors and evaluate the extent to which these can be reconciled when it comes to the use of EO in conservation.

To understand experiences and notions of (in)justice within study landscapes, we will carry out a **period of fieldwork (comprising semi-structured interviews and participant observation; M18-27)** through which we will draw out lived experiences of EO-data-driven injustice. The understanding gained, in combination with the datascape maps developed in WP1, will be the starting points for a **second workshop in each landscape focused on envisaging alternative datascares (M24-26)**.

In this workshop, we will use the revealed structure of the current datascape as a platform to identify examples and associated drivers of perceived justice and injustice. We will work with landscape working groups to identify the changes needed to make datascape more just and reflect on the potential challenges of making these changes. This approach is modelled on an ongoing collaborative process between environmental data justice scholars (including Sauls and Pritchard) and the United Nations Environment Programme's World Conservation Monitoring Centre (UNEP-WCMC), exploring the data justice risks within the World Database on Protected Areas.

To deepen our understanding of how data producers, analysts, and users outside study landscape think about the intersection of EO, justice, and conservation, we will also conduct **an online survey and set of semi-structured interviews (M27-32)** and **convene workshops at four relevant conferences (between M25 and M37)**. We will model the online survey and dissemination approach on other survey tools used to interpret underpinning philosophies in conservation, such as the Future of Conservation Survey²⁵. Conference workshops will focus on events widely attended by EO analysts, data producers, and conservation researchers, such as SatSummit, UK Earth Observation, the Global Land Program Open Science Meeting, and the International Conference on Conservation Biology. These engagements will help to advance discussions of justice and EO in conservation with key actors involved in global EO datascape, in particular extending beyond current technocentric narratives of EO as purely a solution rather than a potential threat to social justice.

The outcomes of the workshop, semi-structured interviews, surveys, and side events will be used to draft **a synthesis paper for each landscape** summarising drivers of perceived (in)justice, and the barriers to mitigating injustice and upscaling just practices. These working papers will later form the basis for academic journal submissions. Two further academic outputs will emerge from this WP: (i) **a conceptual paper bringing together research on data justice and plural notions of data justice**, and (ii) **a quantitative analysis of the results from our survey on notions of justice in the conservation EO community**.

WORK PACKAGE 3: TRANSFORMING 'LOCAL' DATASCAPES (months 38-54, co-ordinated by Lugasa and Foster) will identify and co-develop strategies by which EO can facilitate socially just conservation in the four study landscapes as well as strategies to mitigate perceived injustices arising from EO technologies and their use (RQ4). We will bring together actors from within and beyond landscapes to identify points and methods for intervention at all supply chain stages, both within and beyond our case study landscapes. Our co-development approach in WPs 3 and 4 is informed by the Principles for Digital Development²⁶ – recognising that while many of the ultimate outputs may not themselves be digital products, they will all be focused on advancing justice in the use of digital technologies and data. WP1 and WP2 have addressed the key principle of 'understand the existing ecosystem'. WP3 is framed around the principles of designing with the user, building for sustainability, reusing and improving approaches that are already successful, and engaging collaboratively both within and beyond landscapes.

The synthesis papers developed in WP2 will inform our **third workshop in each landscape (M38-39)**. In this workshop, we will explore and define mutually-agreed solutions to data justice challenges that are priorities for landscape residents. Workshop participants will be given decision-making power on how funds for output development should be allocated, which helps break down the asymmetries of power between researchers and participants. Unlike previous within-landscape workshops, this engagement will include participants from other parts of data supply chains, including EO data providers and generators, who will be essential for developing new ways of working with and utilising EO data that are technically feasible and sustainable post-project.

Following the workshops, co-development of mutually-agreed outputs will be facilitated by the JEO4C PDRAs through **a series of monthly virtual engagements for each landscape**, coupled with asynchronous interactions via virtual discussion forums (hosted on project website) or online collaboration spaces (e.g., Google Earth Engine to co-produce web apps). Virtual fora will provide spaces for iterative and reflexive feedback through which outputs will be refined and tested with landscape actors, while also ensuring that those who will be using outputs have the necessary trust, confidence, and capacity to apply and sustain outputs in conservation decision-making post-project. We will also complement this online process with discussions in-person or by phone if needed to facilitate participation of actors not able to access online discussion spaces. A **final workshop in**

each landscape (M51-52) will be an opportunity for all participants to approve **landscape-specific outputs**, as well as to discuss learnings and next steps from the project more broadly.

While co-development has often been framed as a panacea, it is also important to note how co-development approaches are shaped by contextual factors and relationships of power²⁷. In keeping with the approach taken in Sauls and Pritchard's aforementioned collaboration with UNEP-WCMC, the team will **document the approach taken in meeting notes and research diaries** and will use these notes to **develop reflexive appraisals of the possibilities and challenges of co-design in the four landscapes**. This will provide valuable methodological insights for those seeking to advance data justice in EO data practices. This process of documentation will be transparent to all participants, and all participants will have opportunities to participate in the write-up of the reflexive analysis and to be co-authors on the resulting publications.

WORK PACKAGE 4: TRANSFORMING THE GLOBAL DATASCAPE (months 36-57, co-ordinated by Pritchard and Prado Córdoba) will upscale the outcomes from our case study analyses to develop new tools and approaches that enable those researching, practicing, and impacted by conservation to identify and address EO data injustices in landscapes globally.

We will begin by bringing together actors from different landscapes in **spaces of cross-contextual learning (M36-46)**, to identify and share solutions to common injustices resulting from use of EO tools and data in conservation policy and practice. These engagements will focus on shared points of interest, such as specific technologies or resources (e.g., water), and will follow a 'walkshop'²⁸ format, in which participants spend time learning together within landscapes. These kinds of engagements are particularly powerful for facilitating South-South learning.

To broaden the scope of our project further, we will also commission **a set of 'deep dive' projects led by early-career researchers in JEO4C's four study countries**. We will support two cohorts of 8 ECRs (2 per country and cohort), providing stipends and research costs for 3-6-month projects focusing on themes emerging from the JEO4C research program. Each cohort will conclude with an in-person writing workshop, through which ECRs will present and gain feedback on their work from senior members of the project team and advisory board, document shared learning about pathways to just use of EO data in conservation and receive mentoring to develop their research from data to publishable papers. These projects have the dual values of developing the capacities of early-career researchers based close to the study areas and providing a flexibility to respond to deepen analyses of key cross-site justice issues arising in our four case study sites and wider global EO datascares.

To upscale the evidence and impact drawn from our comparative analyses and engagements, we will convene **an international workshop (M47-48)** involving participants from all data supply chain stages. A key goal for this workshop will be to define the content of an open access **Just Conservation Datascares Handbook and associated set of training materials**. These outputs will provide a legacy toolkit from JEO4C, synthesising its key conceptual, empirical, and methodological findings within the three themes of revealing, reimagining, and transforming EO datascares in a format accessible to those not trained in critical social sciences. In the final year of the project, **we will utilise the Handbook to affect change in practice across the conservation EO datascape**. This will include co-creation of more just codes of practice related to data provision and privacy protection, along with working with partners to embed best practice in training of the next generation of EO researchers (e.g., the NASA DEVELOP programme, represented by Amanda Clayton on our advisory board).

Finally, our international workshop will serve as the inaugural meeting of a permanent **EO Data Justice International Working Group**, which will be embedded within the Global Land Programme partnership. Over the final year of the project, **we will use the Working Group as a mechanism to share and expand learning beyond our four core case study sites**, in particular identifying parallels and potential differences in just EO data practices with other conservation sites. This work will **draw on the existing networks of our partners and other members of our Working Group** (e.g., UK National Parks; the wider Central American networks of The Nature Conservancy), including **catalysing collaboration around shared points of interest**, such as particular ecosystems (e.g., coastal wetlands, tropical forests), conservation models (e.g., private protected areas), technologies (e.g., satellites, drones) and kinds of conservation conflicts (e.g., between agricultural land uses and stricter conservation measures).

OUTPUTS AND IMPACTS

Our project will make three major academic contributions which will advance work both on conservation and on data justice. **First**, we will transform the empirical evidence base about how EO technologies and data are being used for conservation, and, crucially, with what consequences for those living in conserved lands. **Second**, we will develop new ways of thinking about and designing for data justice that recognise the plurality of conceptualisations of justice. **Third**, our project will be the first large-scale comparative analysis of the social implications of EO technologies and data across multiple conservation landscapes. Together, these contributions will translate into unique insights into how and why data consequences, notions of data justice, and strategies to advance data justice differ across conservation geographies.

JEO4C will generate a minimum of 20 papers in high-impact interdisciplinary and conservation journals. This includes our cross-cutting analysis of conservation datascape in the four landscapes, which we will submit to *Proceedings of the National Academy of Sciences*, and our theoretical paper on recognising plural notions of EO data justice for conservation, which we will submit to *Global Environmental Change*. We will also present the results of our work at relevant conferences focusing on EO (SatSummit, Living Planet Symposium, SPIE Remote Sensing Conference), conservation (International Conference for Conservation Biology, British Ecological Society) and environmental social sciences (POLLEN political ecology conference, FLARE forest livelihoods conference). We will also develop a further dedicated special issue in a journal such as *Conservation Letters* or *Big Data and Society* to highlight outputs from our ECR-led commissioned projects.

Our work will have **wider societal impact on conservation policy and practice** by mitigating data injustices and building on the examples of data practices that advance socially just conservation identified through our project. The strong co-development approach running throughout our project means that we cannot pre-determine landscape-specific outputs, as these will be shaped by the priorities and constraints of the participants. Possibilities include new sets of guidelines and best practice principles, new ways of framing or making decisions based on data, new rules around data access and management, or new ways of presenting or integrating data within decision-making structures which help redress injustices. The research team are well equipped to be agile in response to local needs emerging during the project, with strong experience in co-development with conservation actors (Enns, Sauls), working with conservation partners to develop strategies for advancing data justice (Pritchard, Sauls), developing new EO data applications (Foster), communicating EO to non-academic audiences (Sauls²⁹; Pritchard²³⁰), creating outputs for policymakers and intergovernmental organisations (Oldekop, Prado Córdoba) and building communities of practice focused on data (Ryan).

To promote broader reform in the global conservation EO datascape, we will work with participants from all data supply chain stages to create the Just Conservation Datascape Handbook, along with a set of training videos and written materials for students, researchers and practitioners using EO for conservation to highlight how these data can be used to ensure more socially just outcomes for communities. These materials will be made freely available online on an appropriate platform (e.g., GitHub) and we will work with key partners (e.g. NASA Develop) to encourage uptake of these materials in student training. In addition, a further major legacy output of our project will be a permanent International Working Group on EO Data Justice. This Working Group will be embedded within the Global Land Program partnership, which will integrate our work with an established global community of land systems policy and practice who collectively shape major worldwide initiatives such as the UN Decade on Ecosystem Restoration. These large-scale international outputs will also benefit from the involvement of Dan Brockington and Chris Sandbrook on our project advisory board, both of whom are currently leading major projects exploring the justice issues raised by the use of data in global spatial conservation prioritisation analyses (Brockington as the lead on the ERC-funded CONDJUST project, Sandbrook as the lead on the SNAPP-funded 'Social implications of 30-by-30' project). The handbook and working group therefore have the potential to bring together complementary outputs and synergistic learning from multiple large-scale research initiatives, each of which is contributing in different ways to advancing understanding of the social benefits and risks of data use in conservation.

There will also be **ongoing dissemination throughout the project** via the project website, Twitter account, blog posts, and articles on non-academic websites such as *The Conversation* and

Mongabay. Dissemination will be supported by the communications team in the Global Development Institute and by Policy@Manchester. So far as possible, all outputs will be produced in the main project languages of English, Spanish, Catalan, and Swahili.

The direction of the project will be guided by two levels of advisory committees. First, our **international advisory board** will provide input on the academic direction of the project, as well as brokering connections to data producers and analysts and the conservation community. This board is formed of conservation researchers (Dan Brockington, Universitat Autònoma de Barcelona; Jennifer Devine, Texas State University; Rosaleen Duffy, University of Sheffield; Joan Martinez-Alier, Universitat Autònoma de Barcelona; Chris Sandbrook, University of Cambridge), participants working in international conservation policy and practice (Edwin Castellanos, The Nature Conservancy; Ramson Karmashu, ICCA Africa; Anne Larson, Centre for International Forestry Research; Iliana Monterroso, Climate and Land Use Alliance), and experts in EO data production and analysis (Ryan Avery, Development Seed; Amanda Clayton, NASA DEVELOP; Tom Higginbottom, Airbus UK). Second, our engagements through the first year of the project will support the formation of **landscape working groups**, which we will expand and collaborate with over the course of the project as part of the identification and co-development of solutions to landscape-specific justice issues. These groups will be formed of our existing connections in these landscapes with the addition of key actors identified through the first 2-3 years of the project.

RESEARCH TEAM AND PROJECT MANAGEMENT

The research team is formed of Rose Pritchard (University of Manchester, UK; PI), Tim Foster (UoM; Co-PI), Charis Enns (UoM), Laura Sauls (George Mason University, USA), José Pablo Prado Córdova (Rafael Landívar University, Guatemala), Klerkson Lugasa (independent consultant, Kenya), Marina Requena Mora (Jaume I University), Casey Ryan (University of Edinburgh, UK) and Johan Oldekop (UoM). The team brings together academic expertise in environmental social science (Prado Córdova, Enns, Lugasa, Requena Mora), environmental, digital, and data justice (Pritchard, Enns, Sauls, Requena Mora), and the generation, processing, and analysis of large environmental datasets for policy design and evaluation (Foster, Ryan, Oldekop). The combination of academic and applied experience in the team make it possible to carry out this innovative interdisciplinary project.

Each WP and task within the project (Table 2) has one or two designated co-ordinators. Each study landscape also has two landscape leads with experience working in the case study area: Pritchard and Foster in the Peak District National Park; Sauls and Prado in the Maya Biosphere Reserve; Enns and Lugasa in Mount Kenya Ecosystem; and Marina-Requena and Foster in Albufera. Landscape leads will work closely with WP/task leads to deliver the within-landscape components of the work. Our distributed leadership structure and the collaborative approach taken to all elements of the project is designed to safeguard against the project reproducing the North-South asymmetries of decision-making power which are a common problem in international collaborations.

Research for WP1 will be carried out by landscape leads and task co-ordinators. Support for the scoping review will be provided by two short-term research assistants at UoM. Two 4.25-year PDRA's will be recruited to focus on the work required in WPs 2 and 3 in collaboration with landscape leads and task co-ordinators. The first PDRA will be based at UoM, the second at Rafael Landivar in Guatemala. These PDRA's will have the opportunity to develop a strong understanding of notions of justice and a strong set of relationships within each study landscape through WP2, which in turn will facilitate the co-development work required in WP3. The UoM-based PDRA will focus mainly on the Peak District and Mount Kenya study landscapes, while the PDRA based at Rafael Landivar will focus mainly on the Maya Biosphere Reserve and Albufera National Park (both sites where fluency in Spanish will be highly advantageous). WP4 will be led by Pritchard and Prado Córdova, closely supported by Oldekop and Ryan who both have the convening experience and global connections needed to scale up our research impact (Ryan is a Steering Committee member for the Global Land Program, the anticipated home of our permanent EO Data Justice Working Group; Oldekop currently leads the UKRI-funded international project 'Sustainable Forest Transitions', which is using large datasets to understand drivers of forest change, and is a co-ordinating committee member in key networks such as the FLARE forest-livelihoods network). Additional support for primary data collection in WPs 1 and 2 will be provided by research assistants in Kenya and Guatemala,

recognising the larger scale of these sites. The Nature Conservancy has agreed to fund research interns in Guatemala to support primary data collection should this grant be awarded, at a value of £4800 per intern per year.

Table 2 Summary of tasks, responsibilities, and key outputs in the JEO4C project

Task	Co-Ordinator(s)	Months	Key Outputs
WP1 Revealing EO Datascapes (co-ordinators Enns and Foster)			
1.1 Scoping review	Enns	3-7	Datascape maps for each study site
1.2 Initial site visits	Landscape leads	4-6	5 academic papers (4*case study papers; 1*comparative synthesis)
1.3 Landscape workshop 1: datascape mapping	Foster	8-11	
1.4 Continued datascape tracing	Enns	12-16	
1.5 Narrative synthesis and write up	Enns, Foster	16-19	
WP2 Reimagining EO Datascapes (co-ordinators Requena Mora and Sauls)			
2.1 Qualitative case study research in landscapes	Requena Mora	18-27	Working paper synthesising drivers and experiences of EO data justice for each landscape (for later adaptation as journal article)
2.2 Landscape workshop 2: imagining alternatives	Sauls	24-26	
2.3 Online survey and semi-structured interviews beyond landscapes	Sauls	27-32	2 additional academic papers (conceptual paper on recognising plurality in data justice; mixed methods analysis of justice notions in the conservation EO community)
2.4 Conference side events	Sauls	25-37	
2.5 Data analysis and write up	PDRAs	30-38	
WP3 Transforming 'local' EO datascapes (co-ordinators Lugasa & Foster)			
3.1 Landscape workshop 3: defining outputs	Lugasa	38-39	Co-developed outputs for each landscape (e.g., new guidelines, new information products etc.)
3.2 Iterative co-development process	PDRAs	39-50	5 academic papers (4*reflexive appraisals of co-development approaches; 1*comparative synthesis)
3.3 Landscape workshop 4: confirming outputs	PDRAs	51-52	
3.4 Data analysis and write-up	PDRAs, Lugasa	53-54	
WP4 Transforming the Global Datascape (co-ordinated Pritchard and Prado Córdoba)			
4.1 Cross-contextual learning engagements	Prado Córdoba	36-46	Just Datascapes Handbook and training materials
4.2 ECR 'deep dives' and writing workshops	Pritchard, Foster	12-46	Permanent EO Data Justice Working Group in the GLP
4.3 International workshop	Pritchard, Sauls	46-48	Special Issue of journal showcasing work in deep dive projects by ECRs
4.4 Production of Just Datascapes handbook and materials	Pritchard, Oldekop	49-57	
4.5 Establishment of permanent working group	Pritchard, Ryan	By M50	
WP5: Project Management			
5.1 Ongoing project administration	Pritchard, Foster, project manager	0-60	Datasets and metadata for deposit in appropriate repository (e.g., ReShare service)
5.2 Ongoing dissemination	Pritchard	7-60	
5.3 Research team workshops	Pritchard, project manager	Annual	
5.4 Online advisory board meetings	Pritchard, project manager	Every 6 months	
5.5 Team capacity development	Oldekop	7-60	
5.6 Project Wrap-Up	Pritchard, Foster	57-60	

Pritchard and Foster will act as PI and co-PI for this project, reflecting our commitment to embed interdisciplinarity throughout the project structure. Pritchard has been at the forefront of developing work on conservation data justice and initiated the earlier collaborative project ('Conservation Goes Remote') which led to the current proposal. Foster has leading expertise in EO and natural resource management and in large project management, including leading work packages on rural livelihoods,

land, and water use monitoring for the £9.8 million GCRF-funded FutureDams project and £4.6 million UKRI and European Commission-funded TRANSCEND project. Ryan will also provide guidance on over-arching project management, drawing on his experience managing multi-million-pound research projects (including in his current role as PI on the £3.6 million NERC-funded SECO project), while Oldekop will lead project capacity development activities. The PIs will be supported by a dedicated 3.5-day-per-week project manager based at UoM.

The full project team will meet online once per month to maintain coordination across the project, with more regular bilateral engagements between team members as needed. We will also organise annual project meetings, held in different case study landscapes and scheduled in advance of critical changeover points in the project (such as the transition between WPs 1 and 2) when there is a need for focused, collaborative methods development and planning. International advisory board members will be invited to attend the first of these workshops in person, with subsequent meetings organised in hybrid format to allow advisory board participation. The international advisory board will meet online every six months over the course of the project to discuss project progress.

CAPACITY DEVELOPMENT, DIVERSITY, AND INCLUSION

The core team for this project includes many researchers less than 6 years from PhD award (Pritchard, Sauls, Enns, Lugasa, Requena Mora, and Sauls,), the majority of whom identify as women. The team includes researchers from all case study landscape countries: Prado Córdova (Guatemala), Requena Mora (Spain) and Lugasa (Kenya). We are committed to representation of diverse perspectives and will reflect this in our hiring practices and advisory group composition.

Capacity development is woven throughout the project structure. Oldekop, Ryan, Prado Córdova and Foster will draw on their management experience within large-scale research projects to guide and mentor earlier-career team members (Pritchard, Enns, Lugasa, Requena Mora, and Sauls) as they build project management and leaderships skills. Earlier career Co-Is will all take on leadership responsibilities for WPs and specific tasks, in collaboration with more established colleagues.

We will take advantage of the UoM Prosper program to prepare a professional development plan for the UoM-based PDRA and adapt this approach to develop an equivalent plan for the PDRA based at Rafael Landivar. We have budgeted resources for each PDRA to support training, networking, and conference attendance. The capacity development impact of our project is extended further by the allocation of resources for 'deep-dive' projects led by early-career researchers, who will gain hands-on experience conducting multi-disciplinary action research, professional development and mentoring with writing and presentation skills, and opportunities to establish connections with world-leading conservation researchers and practitioners outside their immediate local environments.

Our capacity development initiatives are also not restricted to the project research team. The co-development process in our project will have the benefits of building awareness of social science and data justice issues among more technically oriented actors, as well as building technical and data literacies among conservation actors and local peoples. This multi-directional learning approach, alongside legacy outputs such as the Just Conservation Datascape Handbook and online training materials, means that the capacity development impacts of this project will extend far beyond the core project team and the lifespan of the project.

RESEARCH ETHICS

Our project will undergo formal ethics review at the University of Manchester before commencement of primary data collection and will also adhere to the ethical review requirements of national and local research authorities in study countries.

Beyond these formal review requirements, we seek to centre an ethics of care, humility, and respect in the practices of our project. We see framing ethics as a continuing process as essential in participatory and co-development research, particularly when working with marginalised peoples and when project engagements may bring together people with histories of conflict. We follow Tronto's³¹ definition of an ethic of care as 'taking the concerns and needs of others as the basis for action'. This is why our project is designed with the explicit goal of recognising plural understandings of justice

and of developing outputs based on the understandings we gain of local needs and worldviews, rather than pre-determining a set of outputs for each landscape.

To make sure these values are maintained in our approach, we will include ethics as a specific discussion point in our 6-monthly meetings with the project advisory board. We have also designed the project so that landscape working groups and participants are regularly updated on project findings (e.g., the findings from WP1 being used as the basis for the workshops in WP2) and have opportunities to shape project progress and outcomes. Further, we acknowledge the need to be aware of the relationships of power and differences in participation styles which will shape the co-development process in our project³². Identifying the potential risks these might bring and seeking ways to mitigate them, particularly when it comes to enabling meaningful participation of less powerful actors, will be a core goal of the ongoing reflexive appraisal of project activities in WP3.

RISK MANAGEMENT

The main risks we identify in our project (Table 3) are associated with participation, travel, in-person meetings, and the sustainability of project outputs. Our main risk mitigation factors are the depth of the connections we already have in study countries and sites, and the co-development process which has been designed to ensure that outputs are useful, usable, and sustainable.

Table 3 Risks and mitigating factors in the JEO4C planned work program

Risk	Mitigation Measures
Participants in landscapes are unwilling to engage with the co-development process	Choosing sites where we have established relationships with key partners, many of whom have already provided letters expressing a willingness to participate in the co-development process.
Dependencies between work packages and landscapes	- Carefully planning of co-dependencies between work packages. Output development and cross-site synthesis (WP3 and WP4) can proceed based on preliminary datascape mapping (WP1) and synthesis of justice risks (WP2) in event of delays" - Local Co-I's to ensure timely and sufficient engagement of stakeholders and institutions in study sites" - Project team have experience of successfully managing, coordinating, and delivering multiple large multi-institution projects"
Challenges engaging with data producers and analysts outside landscapes	- Involvement of leading data producers and analysts on the international project advisory board - Existing networks of research team, advisory board members and partners
Restrictions on international travel	- Co-Is based in all three of the case study countries - Project meetings and international engagements can all be moved online - Foster has experience remotely coordinating field data collection and running virtual interviews and workshops
Unable to visit research sites	Switch to phone-based interviews and online workshops, recognising risks of lower quality engagements and exclusion of some key groups. Ryan has experience facilitating phone-based research during the Covid-19 pandemic.
Limited current or future potential use of EO data in conservation decision-making	- Study sites have been carefully selected to ensure EO data use is already ongoing - Sites are all in conservation areas where local actors have identified EO data use as a priority to support policy design and implementation
Inadequate uptake of outputs and recommendations in long term conservation practice	- Co-development approach to ensure outputs reflect local contexts and challenges related to just EO data practices - Established expertise of project team in co-designing and co-developing research outputs with local stakeholders - Sustainability strategies to be confirmed before committing to the development of any project output