Posthumanist Care and Ecologies of Empathy: Investigating Design Potentials for Nature:Culture HCI

Pedro Galvão-Ferreira*
ITI/LARSyS, Instituto Superior Técnico, U. Lisboa
Lisboa, Portugal
pedro.galvao.ferreira@tecnico.ulisboa.pt

Vera K. G. Fearns
ITI/LARSyS, Instituto Superior Técnico, U. Lisboa
Lisboa, Portugal
vera.fearns@tecnico.ulisboa.pt

Nuno Nunes
ITI/LARSyS, Instituto Superior Técnico, U. Lisboa
Lisboa, Portugal
nunojnunes@tecnico.ulisboa.pt

Valentina Nisi
ITI/LARSyS, Instituto Superior Técnico, U. Lisboa
Lisboa, Portugal
valentina.nisi@tecnico.ulisboa.pt

ABSTRACT

HCI nature:culture dialogues have recently gained traction, highlighting ample opportunities for investigation. In this paper we look at the potential of locative games in fostering caring engagement with natural/cultural heritage. We present the results of a contextual study that explores the nature:culture duality of the *Levada* walks on Madeira Island and their intrinsic playfulness as a natural landscape. Through a combination of narrative self-reports and cultural probes, we conducted an on-site investigation of the motivations and embodied experiences of hiking these trails, distilling an empirical epistemology of human-nature interactions. By unpacking the various realities and tensions on the ground through a feminist ethics of care and posthuman lens, we provide insight into the design of future locative interactive technologies to support and encourage human-nature interaction. Our findings address and promote values of engagement and conservation in cultural and natural heritage through a nature:culture continuum.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**.

KEYWORDS

Nature; Care; Feminist Ethics; Heritage; Locative games; Qualitative Methods; Posthumanism

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1 INTRODUCTION

In design research and human-computer interaction (HCI), one emerging area of interest is how digital technology intersects with the natural environments and nature at large [115]. Recently, in light of the joint climate and biodiversity crises, cultural heritage has been looked at as closely coupled with nature [13, 40]. The study described in this paper situates itself at this crossroads, focusing on the potential of location-based interactive technologies, such as locative games (LGs), to enhance engagement with and social visiting practices at cultural and natural heritage sites within a posthumanist paradigm of care [32, 54, 92]. Here we refer to Montola's definition of LGs as games that exert their action across three dimensions: temporal, spatial and social [2, 68, 102]. Therefore, we explore the potential of LGs to change the experience of the places for those present in those locations, be them playing or not [68].

In this paper, we examine the potential of the UNESCO-protected natural sites of the *Levadas* nature walks of the Madeira Islands, an instance of nature:culture heritage [40] that symbolizes the intricate balance between conservation, culture and tourism as a unique setting with the potential for LGs — tools that enable visitors to see places 'with new eyes', revealing hidden aspects and creating new types of interaction [67]. Despite the *Levadas*' dual role as vital infrastructure — water canals — and a cultural-natural asset, these sites still face tensions between conservation needs and tourism demands [35, 73].

1.1 Research questions and design contributions

This paper is driven by an interrogation of the potential role of interactive technologies, and particularly LGs, in enhancing experiences, conservation efforts and visitor engagement at cultural and natural heritage sites. Focusing on nature:culture engagement and visitor experiences at such sites, we ask how location-based solutions foster caring engagement with natural and cultural heritage, specifically in the context of the *Levadas* of Madeira Island, as well as what the motivations and embodied experiences of those walking the *Levadas*, and how a nuanced understanding of these experiences can offer design opportunities for engaging in location-based HCI. Our investigation has also been urged by a need to scrutinize how LGs may navigate the tensions between conservation needs and tourism demands at sites such as the *Levadas*. Ultimately, the current paper looks ahead into the potential implications that our

findings have for future design and development of LGs within natural-cultural heritage sites.

Our efforts align with the current push towards integrating principles of care [54, 62] and sustainability [29] within the field of HCI. Instead of creating technologies to exploit our interactions with nature for mere utilitarian purposes, we aim to foster design innovations and interactions that encourage us to appreciate and nurture the natural environment. Under this lens, the environment and its heritage sites are not viewed as resources to be used at our convenience and for our mere pleasure but as environments of mutual living that deserve our affection and reverence. Consequently, we reject the notion of technology as a means to exploit nature, instead emphasizing its role in facilitating environmentally friendly and compassionate interactions between all its inhabitants and visitors.

Our research holds significance for the design research community as it provides exploratory insight into the intersection of digital technology with cultural and natural conservation, a critical issue in an era where technology and the environment increasingly intersect [23]. We hope that the empirical insights gained will be pivotal for natural heritage conservation, enhancing visitor experiences while contributing to our understanding of how digital interventions can sustainably enhance local values and economies.

Our methodologies include on-site studies with various participant groups at the *Levadas*. To support this approach, we employed qualitative tools — visitors' narrative self-reports and cultural probes (sensory maps and visitor postcards) — to capture a holistic view of visitor motivations and engagements with nature:culture.

The paper is structured to first delve into the theoretical background and literature review, followed by a methodology section. We then present our findings and discuss their implications for HCI, conservation and tourism. Finally, we conclude with reflections on potential technological interventions in enhancing people's experiences of, and relationships with, nature.

2 BACKGROUND AND RELATED WORK

This research was motivated by prior work using technology to tackle the disconnect between humans and nature, focusing on LGs [4, 16, 27]. In the following, we summarize the related work and give contextual information to this paper's research program.

2.1 Matters of care: a posthumanist and feminist ethics for nature engagement

Tourism and conservation can coexist beneficially, with engaging experiences at natural heritage sites encouraging visitors to support conservation efforts [117]. Despite growing awareness of biodiversity issues, the disconnect from nature remains a complex challenge, exacerbated by diminishing direct human interactions with natural environments. This trend, noted by ecologists Soga and Gaston, has led to decreased public health, well-being, and pro-environmental behaviors, underscoring the urgent need for re-engagement with nature and a solution for this 'extinction of experience' [15, 63, 90, 100].

A major playground for human-nature interactions, outdoor activities in natural landscapes partly tackle the disconnect with nature by offering significant health and well-being benefits, enhancing mood, cognitive function, and reducing stress and depression [5, 42, 55, 94, 103, 118]. Still, they are also intertwined with cultural heritage, reflecting a Western dichotomy that separates nature from culture, with the former often seen as a resource for human benefit or conservation [13, 50]. This perspective, honed within our Anthropocene era, highlights the profound impact of human activity on nature, urging a reevaluation of nature as part of our heritage and emphasizing a collective responsibility towards its preservation [20, 59, 81].

Recent work has mindfully investigated the potential of human-nature interactions in inspiring "a new wave of joyful forest technology that transcends techno-solutionism and focuses on alternative values of joy and care" [3], attempting to reconnect urban populations with nature [111], support conservation of endangered wildlife [79] or look into gardeners' biodiversity relations [93]. While it has been suggested that technology can enhance our relationship with nature [108], the effectiveness of these tools in fostering nature connections is debated [96]. Such preoccupation with caring for — and enjoying the experience of — nature has drawn from feminist and posthuman insight into human-nature and nature/culture dyads (or, as some would argue, continuum) [34, 54, 71, 97, 104], "showing how everything is closely connected within a complex system and demonstrating the need to converge different viewpoints and movements that have similar and coherent aims at their base" [51].

As a meta-ecological framework, posthumanist care extends beyond traditional human-centered approaches to include the agency and value of non-human entities, emphasizing ethical and relational engagement with the more-than-human world while recognizing the interconnectedness of all life forms [54]. Caring within this context manifests as active practices that honor the intrinsic worth of nature and encourage mutual respect and sustainable interactions across species, enhancing conservation efforts by shifting the focus from purely human interests to a more holistic approach that values the well-being and agency of the more-than-human world [49, 54, 93]. By fostering collaborative stewardship and ethical responsibility, a posthumanist care ethics challenges traditional human-centered views, emphasizing the interconnected, holistic relationship between humans and the broader natural world and is attentive to more-than-human perspectives as it recognizes the agency and value of non-human entities [6, 11, 24, 54, 89]. As articulated in Bellacasa's *Matters of Care* [89], for instance, a posthumanist ethics of care subsequently emphasizes a relational approach that actively engages with the world in ethical and political ways.

Attitudes to care have, for instance, demonstrated the importance of recognizing diverse interdependent temporalities and disrupting anthropocentric progress-driven models [88] and encouraged expanding the moral community of care to include non-human persons [11]. By emphasizing learning to care for non-humans as kin, practices of care make it possible to "embrace diverse kinds of more-than-human entanglements" [24, 107]. Extending these insights into the generation of locative HCI experiences suggests the potential of meaningful, reciprocal interactions with non-human entities.

Our study highlights how design directions in locative HCI can integrate feminist care ethics by prioritizing empathetic and ethical interactions with both natural and cultural heritage that are also equitable, socially just and attentive to diverse experiences. By acknowledging the complexities and tensions inherent in the landscape, our research opens up possibilities for technologies that honor and support the agency of non-human entities, while also fostering respectful, collaborative relationships among visitors, building on work centering research in HCI and interaction design around concerns for care and our successful and fruitful coexistence with the more-than-human entities in our planet [19, 62]. Additionally, the focus on the playful potential of the *Levada* walks aligns with feminist care ethics' emphasis on creativity and emotional engagement as part of caring practices, opening space to challenge traditional conceptions of care [49]. Suggesting potentials for the design of locative technologies that encourage playful, immersive experiences, this study challenges traditional human-centered approaches and contributes to a more dynamic, ethical engagement with both natural and cultural heritage [45, 109], while opening new avenues that promote a sense of stewardship and connection with nature and culture.

2.2 Locative technologies for nature

Pyle's formulated 'extinction of experience' — the "ongoing alienation of humans from nature" [90, 100] — risks biodiversity conservation and highlights the need to understand and enhance these connections [101]. In this paper, we investigate how a deeper exploration of the dynamics of human-nature relationships may inform the design of technologies that enrich these interactions. Recently, nature-inspired HCI strengthening human-nature bonds has flourished, with attempts at linking HCI to posthuman ecologies emphasizing the role of technology in ecological storytelling and nature connection [18, 25, 37, 54, 61, 66, 75, 86, 95]. The application of augmented, virtual and mixed reality (AR, VR and MR, respectively) hold promise for tackling environmental issues, both in promoting awareness and action for nature and its ecosystems [91]. While recognizing that the use of these technologies in nature may represent a "double-edged sword whose implementation warrants as much attention in HCI as in environmental science" [84] or promoting a loss of contact with the lived experience of nature at the expense of an intense use of technology [53], the possibilities afforded by the potential immersion in more-than-human realities should be investigated for their promotion of involvement with natural spaces [1, 30], particularly via interactions that do not require players to look at their screen while in the wild [57].

Extending on the liminal interactive space between humans and technology [112], current HCI research has been proposed as undergoing a fourth wave in which humans, more-than-humans and digital technologies are appreciated as entangled [39].

In this entangled space, LGs represent a fusion of virtual and physical realms, offering humans potentially immersive and interactive experiences that overlay digital content onto complex ecosystems of real-world and more-than-human environments [25, 41, 121]. Using GPS and other location-based technologies, LGs enable players to interact with virtual elements within specific physical locations, such as engaging in geocaching, scavenger hunts, and narrative adventures that unfold as they traverse different areas [31, 65, 86, 121]. LGs also facilitate "placemaking through play, enhancing the careful processes that form places out of layered networks of affection, habit, and social bonds" while fostering motivation in players who interact with a narrative dispersed across a physical geography [33, 64], allowing participants to "rediscover familiar places and see hidden relationships" [67]. In particular, heritage LGs often incorporate digital guided tours, interactive educational experiences, and narrative gaming strategies, transforming heritage sites into dynamic engagement spaces [12, 22, 76, 82, 85, 114]. Research has also highlighted the significant impact of LGs on user engagement, stimulating cognitive and motor skills, and creating emotional bonds between users and the locations they explore [14, 21, 41, 119], as these technologies merge storytelling with physical exploration, making experiences more memorable, and encouraging repeat visits and positive recommendations [44, 60]. Furthermore, LGs allow for unpredictable play beyond navigation [72], enhance social interaction while promoting group participation, collaboration and a sense of community [70, 74, 77, 80, 83, 120].

LGs are thus particularly promising in addressing the human-nature disconnect. By integrating game mechanics with physical outdoor activities, LGs can motivate people to explore natural environments, enhancing their connection to these spaces while fostering a sense of care for them and promoting engagement with nature through the liminal space between player and narrative [54, 58]. By focusing on the application of LGs, we aim to reverse nature disengagement and support conservation efforts through digital interventions [105, 119], providing implications for the design of LGs with a clear agenda for "societal impact and cultural values" that "spread awareness about [nature preservation]" [56].

However, the consistent application of LGs in natural heritage sites, and the development of effective digital narrative strategies for engagement, require further exploration [26]. By weaving narratives and challenges into specific locations, these HCI tools encourage players to experience the more-than-human networks firsthand, fostering a sense of oneness with the planet we inhabit [18, 105].

3 DATA COLLECTION AND ANALYSIS

The present research methodology was carefully crafted to better understand which aspects to consider when designing for engagement in and with the specific cultural and natural heritage site of the *Levadas*. A qualitative on-site research approach was chosen because of its ability to capture individuals' nuanced and subjective realities, allowing for a rich, textured understanding of their interactions with the environment, their motivation and embodied experiences while walking and immersing themselves along the *Levadas* of Madeira. Our engagement with Madeira, as part of the LoGaCulture project, occurred over four months from late summer throughout autumn 2023, when we collected data from narrative self-reports and cultural probes and analyzed them through a reflective thematic analysis during and after the collection.

Our research builds on recent work on care and sustainability within HCI research [29, 54, 62]. As we strive to develop design solutions and technologies that appreciate — and promote sustainable behaviors and engagement with — the natural world of which we are an integral part, our use of cultural probes and self-reports

allows us to delve into the expectations and variety of experience of being in nature:culture. As societies, technology and the myriad relationships with the natural world change, it is important to stimulate tighter connections with more-than-human realities brought about by new approaches to technology [51].

Our study focuses on the Madeira Island *Levadas* as they represent an extraordinary epitome of nature as heritage: man-made irrigation channels that have become integral to the island's tourism and heritage landscape [35, 69, 78, 99]. These channels, dating back to the fifteenth century, serve their primary irrigation function and provide unique trekking experiences through Madeira's diverse natural environments, including the UNESCO-recognized Laurel Forest (the Laurisilva of Madeira). The *Levadas* attract a wide range of users and have become a focal point for narratives that enhance the tourist experience, offering deep immersion in the island's natural beauty [36, 73, 106]. As simultaneously natural and cultural sites, the Madeira *Levadas* are — as we explore in this study — a perfect test case where a community's engagement with local natural and cultural heritage can be investigated, foregrounding spaces for location-based solutions crafted through a posthumanist ethics of care that curates and salvages human-nature:culture interactions.

3.1 Narrative self-reports

At the start of our fieldwork, our data collection was focused on getting first-hand insights from people who would walk the *Levadas* and share their experiences with us through reflective reports. For this purpose, we took over what Cohn calls an "opportunistic spontaneity" [17], while recognizing "the need to expand [our] design practices in ways that respond to the idiosyncratic character of nature-related research, with all its messiness and unpredictability" [107]. Such opportunism acknowledges tracking the traces within the field in a situational openness and productively uses the limits of plannability in the research process. We followed a series of opportunities — from engaging with tour operators, leveraging walks with friends and family, to organizing Levada trips as part of the Câmara de Lobos municipality in Madeira — and asked 19 participants, with ages ranging roughly from 18 to 60 years of age, to write and hand in a self-report about the experiences of their Levada walk. These reports were collected from a variety of participants, from single individuals to couples, family members and groups of friends (typically brought together by the Câmara de Lobos municipality as part of wellness programs). Through this practice, we collected self-reports from both Madeira locals and tourists, varying in length and style of writing (some reports were brief and straightforwardly factual, while others stretched in longer detail, providing personal reflections and autobiographical stories in more elaborate prose), covering walks across eight different *Levadas* of differing durations and difficulty (including Levada dos Balcões), in August 2023.

3.2 Cultural probes: visitor postcards and sensory map

Following these early-stage explorations, cultural probes were developed (under review elsewhere) as a tool for collecting more specific information about the experience of visiting a Levada and later informing the design of heritage-related digital games. The development of these tools built on feminist posthuman approaches, focusing on the relational aspects of nature:culture to elicit sensory, speculative, situated, embodied and affective aspects relating to nature:culture heritage(s). Our cultural probes built on research that highlights such instruments as meaningful research tools for eliciting subjective, contextual, and often obscured aspects of everyday human experiences for inspiring design processes [43, 52], and argue for the importance of pluralistic and situated interpretations, adoptions, and adaptations [122]. In the context of our exploration, and with an interest in more-than-human aspects at cultural and natural heritage sites, these in-the-wild approaches [58] seemed promising in exploring various aspects that could later inform our design.

The probes here implemented consisted of a set of visitor postcards and a sensory map. The sensory map was designed to provide rich descriptive data about the multi-sensory experiences of the *Levadas*, capturing not just what the participants saw but what they heard, smelled, touched, and felt emotionally. The map contained detailed instructions on how to perform the activity, advising participants to stop for a total of five times across the hike, writing down the approximate location of each stop; in each of the five stops, participants were invited to reply to a set of prompts/questions ("What can you see? List your 5 favorite things"; "What can you smell?"; "What can you hear?"; "What can you touch or feel?"; "How does it feel to be there?"; "How is the space around you?"; "If you have to remember one thing from this place, what would it be and why?"). The ten postcards invited participants through ten questions to share their experiences, hopes, thoughts, and expectations (1) If the *Levadas* could talk, what would they tell you?; 2) What would you like a future visitor to notice about this place?; 3) What do you particularly enjoy about the Levada and what makes it special to you?; 4) What is sacred to you?; 5) What challenges did you have to overcome to get here?; 6) To some visitors and residents, you are a giant. What do you think the smaller ones make of us?; 7) How would you like to be remembered?; 8) If you could send a message to a visitor in the past, what would you ask or tell them about?; 9) If you could visit the *Levadas* in the distant past or future, what would you imagine seeing and hearing?; 10) How can this place better serve you and what would you like to see improved?) How can this place better serve you, and what would you like to see improved?]; K) Back display of one of the visitor postcards). Both probes were implemented in late November 2023 during two visits to *Levada dos Balcões*, a short 1.5-kilometer trail. A total of 23 participants, with ages ranging roughly from 18 to 55 years of age, were recruited from the University of Madeira local undergraduate population and Erasmus+ international mobility programme, as well as by reaching out to Portuguese and international residents connected to local friends and family, and invited to interact with and fill in these probes. Two researchers accompanied these excursions and were available to answer any questions about the probes but otherwise remained in the background, allowing the probes to speak for themselves.

3.3 Post-*Levada* online survey

After the Levada walks, the researchers asked the participants who interacted with the cultural probes to fill an online questionnaire — responded to by 21 out of 23 participants — containing questions

addressing the experience of walking the *Levadas* (e.g., "How did you inform yourself upfront about the Levada?", "Indicate the main reasons why you were interested in this tour [of the *Levadas*]?", "How do you prefer to do nature walks/hikes", or "Did you come to this Levada walk with any friends/colleagues/family?"), on phone and social media use during the walks ("Did you use your phone during the walk and if yes, what for?", "Did you, or are you planning to share your experiences with others?" or "If you created any social media posts, which social networks did you post in?") as well on the cultural probes themselves (e.g., "Which new perspectives did the sensory map bring to your engagement with the environment?" or "Overall, how do you rate the tool [the postcard probes] to foster imagination towards more inclusive and ecological futures?") and general demographic information.

3.4 Data analysis

The theoretical framework guiding our explorative data collection and subsequent analysis was deeply inspired by posthuman and new materialist thinking [8, 9, 47, 48]. All authors have walked and experienced the *Levadas* themselves. By embracing our position as a determining factor and framing our sense-making as situated and embodied process within an entangled environment [46, 110], this very personal and involvement allowed us to draw particularly deep insights and analytical conclusions about implicit knowledge during the analysis.

Consequently, meaning-making had already started during data collection but intensified during the analysis stage, where we used reflexive thematic analysis (RTA) [10] to examine the data from the reports and transcribed annotated probes collectively. Two authors performed individual coding and clustering of the data from the probes and reports, compared their results, discussed any conflicts and merged their results, which were discussed with the other two authors. In a second round, the authors looked for design potentials that were then discussed and collectively agreed on among all authors. Application of RTA to this data output provided a nuanced and in-depth understanding of human-nature:culture relations. Aside from allowing for flexibility in data interpretation, RTA enabled a comprehensive and multi-layered examination of the data. By allowing for a diversity of themes, we were able to gain a deeper understanding of the complexities of human-nature:culture interactions, which, in their own turn, informed the strategies to foster more meaningful and sustainable relationships with the environment, described below.

4 FINDINGS: DESIGN DIRECTIONS AND POTENTIALS

4.1 Post-Levada online survey data and participant demographics

Responses to the experiential questions of the survey revealed that the vast majority of participants (66.7%) did not inform themselves ahead of their Levada walk (leaving the experience to speak on this own, with little or no prior knowledge of it; with a little over 14% of participants having checked social media and another 14% having sourced information from friends, family or colleagues), a considerable variety of reasons to walk the *Levadas* (in spite of 76.2% of participants pointing our "experiencing nature" as their main driver), the near totality — 90.5% of participants — preferring to do nature walks accompanied by friends, family or colleagues and 76.2% of participants having performed their Levada walks accompanied by friends, family or colleagues. On social media, the vast majority of participants — 85.7% — signaled that they had taken photos during their walk, that they were planning on telling their friends and family about their experience (76.2% of participants, with 28.6% of them replying that they would be doing so through social media) and 68.8% of participants noted Instagram as the social media platform in which they would be creating posts (if they decided to post content on the walk).

Regarding the cultural probes, most participants highlighted the value of the sensory map in driving focus and attention to the experience of the walk (with participants reporting that the map had "made [them] think a little more deeply about [their] surroundings", that it made them "stop, think, look and listen", "slow down and absorb [their] surroundings" or "helped [them] think more about [their] senses and noticing more details"), with a large majority of participants — 61.9% — signaling that the map had directed their attention towards a deeper sensuous experience of the *Levadas*; while on the postcard probes most participants valued their artwork and the way that questions made them reflect on their experience (with participants highlighting "the pictures", "the artwork" and "the images", while others wrote that "the questions made [them] think about things [they] would normally overlook", "made [them] relate the walk to [their] life outside the walk" or that they "liked that [the postcard probes] were stimulating [them] into thinking deeper"), with 47.6% of participants rating these probes with 4 out of 5, and 28.6% of participants with 5 out of 5, regarding the tool's potential to foster imagination towards more inclusive and ecological futures.

Demographics data quantified 52.4% of participants as aged between 18 and 24 years-old, with the next most representative age gap — above 54 years-old — representing 23.8% of participants; the gender balance of participants as relatively even, with 52.4% of participants self-identifying as female and 47.6% as male; and the majority — 57.1% of participants — marking that they were a permanent/long-term resident or natural od the Madeira Islands, with the remaining 42.9% of participants stating that they were non-permanent residents of Madeira.

The following section presents the findings from our RTA [10]. Themes emerging from the self-reports and cultural probes were refined and revisited with a special focus on how design and play potentials — "experiences that are inherently playful and might thus inspire novel and increasingly joyful types of [nature-related] tech" [3] — might be relevant to inspire inclusive, sustainable and more-than-human game design in heritage contexts and make them actionable (Fig. 1), data that was complemented with that derived from the post-walk surveys. This higher-level clustering allowed us to foreground design directions that we present in the following subsections as inspirational starting points for designing LGs in conflicted natural and cultural heritage sites. These themes were: Appreciation of Scenic and Natural Beauty (in which the views and landscape of the *Levadas*, and their role in immersing and connecting participants with these natural spaces and their experiential/pedagogical value, are highlighted); Mindfulness, Relaxation

and Mental Well-being (which speaks to the stress relief, mental health benefits and relaxation experienced during the Levada walks); Relationship with Nature and Environmental Awareness of Human Impact and Preservation (that represents participants' considerable connection with the natural world, including its fauna and flora, and the impact that harmful human activity has in the environment); Exploration, Adventure and Exercise (under which participants signaled their sense of adventure and enthusiasm for discovery and exploration of the *Levadas*, and the role of these walks in their exercise activities); Cultural/Historical Appreciation and Significance (which focused on the historical and cultural context of the *Levadas*, the populations that are connected with them and the stories/lessons that may be learned from them); Personal and Group Experiences and Social Connection (which signaled participants' emphasis on the social dimensions of the Levada walks, including exchanges and interactions throughout the trails); Personal Achievement and Satisfaction (grouping the sense of accomplishment that participants reported and their experience with the striking beauty of the *Levadas*); Reflection, Introspection and Spiritual/Philosophical Insights (which summed the engagement of participants in self-reflection, moments of introspection and instances of pause and insight); Overcoming Obstacles and Physical Challenges (which focused on the occasionally physically demanding nature of the Levada walks and the physical benefits of the associated exercise); Challenges of Navigation, Safety and Accessibility (which summed participants' noting of the navigation and accessibility challenges represented by some sections of some of the *Levadas*).

4.2 Design directions and potentials

Themes were then grouped into design directions — Cultivating Empathetic Connections and Holistic Education; Encouraging Collective Stewardship and Community Resilience; Reflecting and Respecting Diverse Narratives and Agencies; and Fostering Inclusivity and Adaptability in Interconnected Ecosystems — and potentials [3], that aim at foregrounding caring aspects in visiting, thus opening exciting opportunities for design in conservation sites that face the challenge of balancing over-tourism and nature experience and conservation (Fig. 1). The following subsections present these four design directions (DD-1 to DD-4) and articulate the nine resulting design potentials (DP-a to DP-i).

4.2.1 Design Direction 1 (DD-1): Cultivating Empathetic Connections and Holistic Education.

Our first design direction indicated the importance of scaffolding the interaction between visitors and the rich *Levadas* and the Laurisilva forest ecosystem, fostering a deep, empathetic understanding of the natural world and its complex interdependencies. Through engaging locative technologies, this design direction encourages holistic visitor learning, supporting a shift from mere knowledge acquisition to a profound, experiential understanding and emotional connection with the environment.

- **Design Potential a (DP-a): Enhancing Immersive Experiences and Empathy through Multi-Sensory Engagement**
  Participants noted the transformative power of immersive experiences in creating deep connections with nature: by "recognizing [the *Levadas*] as an opportunity [for us] to bond and immerse ourselves in the beauty of nature", pointing out "the sights, sounds, and smells that immersed [them] in the natural environment" or describing the feeling of being "surrounded by lush vegetation [that] offers a unique feeling of being immersed in nature". Both through our sensory maps and postcard probes, they shared moments of awe and wonder in the landscapes (seeing the "Levada adventure [...] not just a physical exploration but also a metaphorical one — a journey of self-discovery, of reconnection with the wonders of nature"), with one describing standing atop a cliff overlooking the forest as a profound experience of aesthetic sublime and connectedness (the "view of the high and imposing cliffs surrounding a lagoon with crystal clear waters [that was] absolutely mesmerizing", meaning that they "were amazed by the beauty of [that] place"), while another reported similar connectedness when surrounded by trees in the forest: "As I immersed myself in the enchanting surroundings, I couldn't help but feel a sense of gratitude for the gift they had bestowed upon us — a remarkable system that not only sustains life but also allows us to experience the natural wonders of Madeira in such a unique way". These experiences led to initial design ideas for intentionally creating immersive environments that nurture empathy and emotional connection with nature. Discussions involved interactive elements such as AI-powered dialogues with nature to encourage visitors to notice the ecosystem and "hear" the forest; an AR treasure hunt that could highlight historical and folk stories along trails, connecting human perception with wildlife experiences; and off-site VR journeys that could simulate the Laurisilva ecosystem's life cycle, offering insights into its delicate balance and creating a feeling of interconnectedness. We noted that VR experiences might also simulate perspectives of non-human entities within the ecosystem, allowing for the scaling of human sizes and temporalities to match the species' perspective for an intimate glimpse into their lives.

- **Design Potential b (DP-b): Creating Dynamic Learning Environments and Co-Learning with Nature**
  Our data revealed participants' interest in informal educational experiences beyond traditional settings (providing "moments of sharing, conviviality, deepening and acquiring knowledge, among others, encouraging, above all, good practices and healthy lifestyles for citizens"), emphasizing experiential learning and hands-on exploration in nature (leaving participants not "want[ing] to stop and just explore and experience the beauty of nature"), combined with expressions of curiosity and discovery along trails (e.g., as one participant approached a man-made tunnel and "a sense of curiosity mixed with a tinge of apprehension washed over [them]"), while encountering unfamiliar plants and wildlife

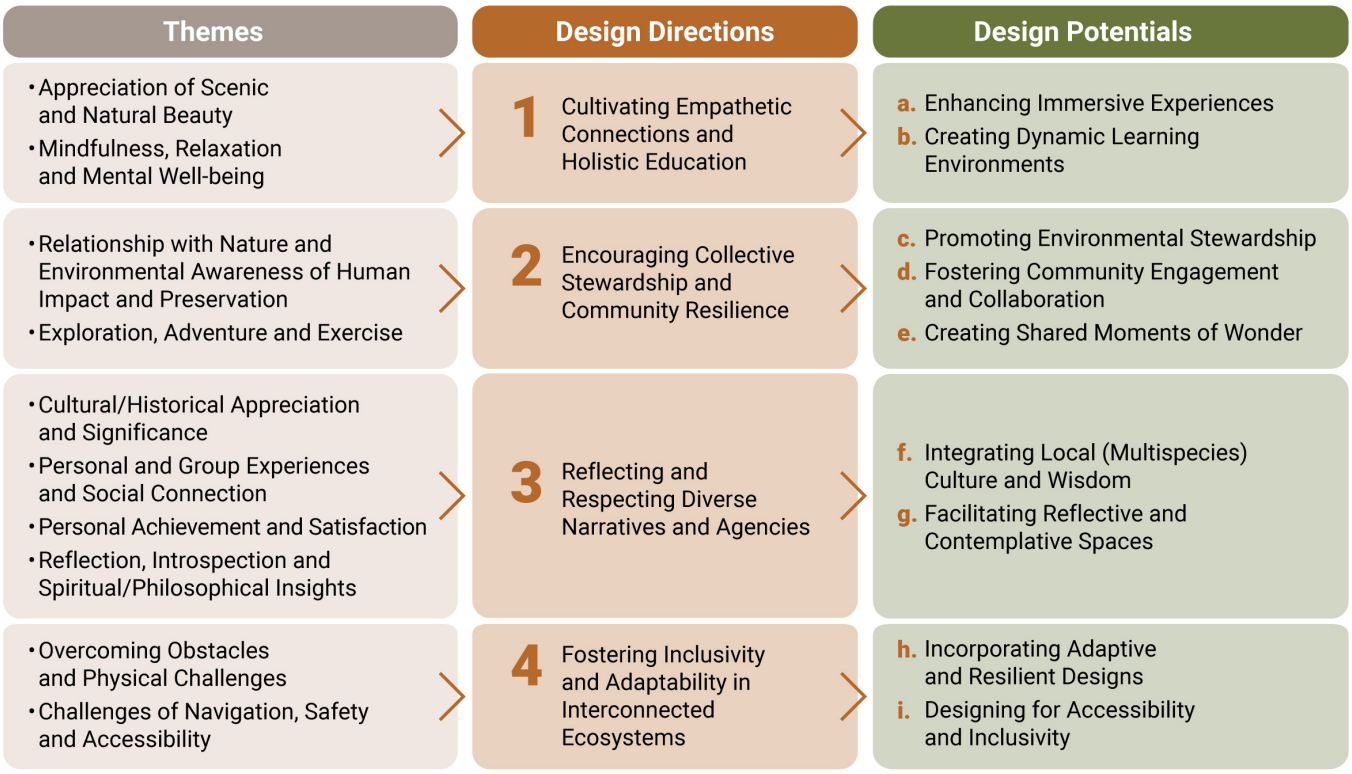

Figure 1: Diagram representing the relationship between the main themes emerging from the self-reports and cultural probes (first column), the four identified overarching design directions (second column) and the resulting nine design potentials (third column).

behavior (listening to "the chorus of birdsong — all of these sensations [becoming] a part of us, woven into the fabric of our being" or remarking on the "profusion of flowers, ancient trees and varied species of plants [that] transformed each step into an exciting journey of discovery"). This enthusiasm should inspire designs that promote co-learning with nature, and which may include interpretive signage and interactive guided experiences for inquiry-based learning. Projects based on locative technologies could weave narratives across museums and sites, connecting the *Levadas*, the forest, and the broader Madeira ecosystem. 'Eco-mystery' games could also challenge players to solve puzzles related to Laurisilva forest conservation, turning environmental stewardship into an engaging adventure. Additionally, an app-based learning game could involve visitors in real-time data collection about flora and fauna, supporting collaboration with local conservation agencies, thus fostering active, participatory learning and directly contributing to conservation research.

4.2.2 Design Direction 2 (DD-2): Encouraging Collective Stewardship and Community Resilience.

Our second design direction revolves around nurturing a collective sense of responsibility and care for the *Levadas* and the Laurisilva forest. This approach is centered on the belief that preserving these natural treasures is a shared duty that binds the community and its members to a common goal. Through LGs, this direction aims to engage people not just as visitors but as active participants and caretakers of the environment, fostering a resilient, supportive community around the conservation efforts.

- **Design Potential c (DP-c): Promoting Environmental Stewardship and Collaborative Caretaking**
  Analysis of participants' data suggested a strong commitment to environmental stewardship, with individuals expressing a desire to actively preserve and conserve the natural environment, with one participant pondering on action that would "help preserve and protect these natural treasures, ensuring that they are accessible and enjoyable for all", another highlighting that they "hope to inspire others to appreciate and protect the natural world around them" while another stressed that the Levada walks had impacted on their "relationship with the natural world and influenced [their] understanding of environmental conservation". Instances of noticing trash led to spontaneous clean-up activities and ideas for restoring disturbed areas along the *Levadas* (as one participant "witnessed the intrusion of plastic into the natural environment") and the need to have more places to safely leave waste (with one participant writing that "people should not throw their trash in the forest", while another

pleaded for visitors to "please put the trash in the trash can!"), reflecting a collective wish and effort to protect the ecosystem. These acts prompted reflections on the importance of collective action and the community's role in safeguarding resources, hinting towards designs that can build on this collective responsibility by offering opportunities for collaborative caretaking within the *Levadas* network. Gamified apps could reward eco-friendly behaviors, guiding visitors through the *Levadas* to identify and report invasive species or pollution, while digital 'conservation quests' could integrate players' actions into real-world reforestation or preservation efforts in the Laurisilva forest. Community-led conservation projects could also engage local and visiting participants in habitat restoration, combined with interactive exhibits that could track and display the collective impact of visitor actions on conservation efforts, providing feedback on the positive outcomes of collective stewardship.

- **Design Potential d (DP-d): Fostering Community Engagement and Collaboration, and Kinship with Nature**
  Data highlighted the importance of the social dimensions of nature experiences, emphasizing camaraderie in fostering a sense of belonging and connection with the environment: the value of "getting to know nature in a way that established a unique connection individually and collectively [...] in addition to developing our social, affective and cognitive domain", a sense that the *Levadas* "formed/strengthened bonds of friendship" and facilitate "both [participants] and the group of friends [they] went with [to fall] in love with the view". Shared exploration along trails created bonds and celebrated the beauty of nature (with one participant writing that they had "struck up a conversation with a woman who had been walking behind [them]", with the other walker's "infectious spirit lift[ing] [their] own, as she sang out loud and shared amusing jokes" and the fact that they "became companions, providing each other with much-needed company for the remainder of the walk"), leading to the recurring theme of a desire to strengthen connections with the natural world, the community and its members (one participant even tells of visiting a shop along a Levada and it "offer[ing] a selection of local produce and delicacies [provided] an opportunity to savor the flavors of Madeira and support the local community that thrived amidst the natural wonders of the island"). Game designs could, we suggest, focus on social aspects by fostering community engagement during walks. For instance, a community-driven game could encourage locals and visitors to share stories and memories linked to specific locations, fostering shared narratives and community bonds; such collaborative projects could blend local folklore with ecological knowledge, creating a layered understanding of the Laurisilva forest and its cultural context. AR experiences could additionally overlay historical images or future scenarios onto the landscape, prompting reflection and dialogue about sustainable futures, albeit mindful that these interventions should be subtle, allowing the natural landscape to dominate technological augmentations.
- **Design Potential e (DP-e): Creating Shared Moments of Wonder that Inspire Collaborative Conservation**
  Participants' walks were filled with moments of wonder and surprise (as when dealing with the unpredictability of the walks, feeling that "curiosity propelled us forward, eager to uncover the hidden wonders that awaited us"), from speculating about the future (when the *Levadas* would become "more accessible [and] more touristic, less natural or forgotten") to imagining ancient wanderers (in a time when "everything would grow very wild, very natural, [with] no trash"), containing experiences of awe that inspired a sense of communal narrative in response to the beauty of the natural world (as one participant affirms, "the connections made and the memories forged during this Levada adventure would be cherished, serving as a reminder of the joy and sense of community that can be found in exploring the wonders of nature together"), encouraging collaborative conservation efforts. Design potentials could include multi-user LGs that allow participants to add speculative layers of agents and stories to the landscape or multi-participant VR experiences could connect people through reconstructed *Levadas* journeys, even from different locations.

4.2.3 Design Direction 3 (DD-3): Honoring Diverse Narratives and Agencies.

Our third design direction is interested in the diverse stories the various actors could tell, honoring the multifaceted nature of the heritage site. Currently, the most salient stories of the *Levadas* underline the utilitarian purpose of these water channels and the grand narrative of the heroic tale of masculine engineering, but equally their biodiversity value [35, 73, 78, 87, 113]. This direction intends to provide a platform for the myriad voices of the region, from more-than-human to the local human communities that have nurtured and been nurtured by the land.

- **Design Potential f (DP-f): Integrating Local Multispecies Culture, Wisdom and Knowledge Sharing**
  Participants showed deep respect for local indigenous culture and traditional wisdom, expressing a desire to learn from and honor these systems (either through the "charming village[s found along the way,] known for [their] traditional crafts and picturesque scenery", the — found in a nativity scene staged in a village along one Levada — "traditional representation of the birth of Jesus Christ performed during Christmas" or the "shelves adorned with locally made crafts, intricate woodwork, and handmade souvenirs whispered stories of the island's rich heritage" found along the way), while encounters with local flora, fauna, and traditional stories sparked curiosity and reflection about the natural world and its cultural heritage (from "the various old and abandoned houses that [are] found along the route, which made [one participant] reflect on the experiences that had already passed there, the stories that these people had to tell" to the "many familiar faces [found along the way and that] allow[ed one participant] to reconnect and reminisce about [their] shared past [as they] embarked on a collective

journey down memory lane", "stories and anecdotes from years gone by filled the air, creating a delightful tapestry of nostalgia" and they "laughed, shared tales of mischief and innocence, and rekindled the bonds that had faded with time"), suggesting the need to foster respectful, symbiotic relationships between humans and nature through knowledge sharing while amplifying the voices of diverse species. This approach encourages a critical reassessment of traditional narratives to uncover biases and promote inclusive interpretations, pointing towards interactive media experiences that can connect human and non-human knowledge, incorporating Madeiran folklore, songs, and dances. These experiences may highlight conservation efforts and natural remedies, offering site-specific or museum-based insights, allowing participants to report back on their newly acquired knowledge in nature, enriching their understanding.

- **Design Potential g (DP-g): Facilitating Reflective and Contemplative Spaces for Co-Existence**
  Participants highlighted the importance of spaces for reflection and contemplation (the participants that can't "help but reflect on the passage of time and the importance of seizing the present moment", the "peaceful evening [that provides] the perfect ambiance to reflect on the experiences, grateful for the spontaneity that had made the day so memorable", the "reflect[ions] on [their] childhood memories of exploring the woods, climbing trees, and discovering hidden streams", the instances spent "contemplat[ing] the emotional solace and inspiration [they] derive from spending time outdoors" or the space to "contemplate nature, namely the fauna and flora that exist[s] there"), with individuals seeking quiet, secluded areas for introspection and spiritual renewal, emphasizing the restorative effects of solitude: from the participant who "consider[s] [the Levada walks] to be an activity capable of achieving so much alone, enhancing a space of self-knowledge, through which we stop to reflect and breathe, to be in silence with nature, enjoying everything it has for us", those who point out the "sounds of silence" and the experience of hearing "nothing, silence", to those who discover "secluded spots along the walk where [they] could sit, relax and tune in to the gentle murmurs of nature around [them]". Designs might create reflective and contemplative spaces, such as sanctuaries for quiet meditation or sound or silent walks through conservation areas, with 'listening spots' additionally attuning visitors to the ecosystem's sounds, fostering a sense of oneness with nature. Locative audio experiences might also offer immersive ambient sounds based on location, enhancing the Laurisilva forest experience, while geo-tagged digital diaries could enable visitors to share reflections, building a collective narrative of personal connections. Additionally, AR layers of information could ultimately be implemented to aid visualization of unseen communications like plant signals or water flow, deepening visitors' understanding of natural processes.

4.2.4 Design Direction 4 (DD-4): Fostering Inclusivity and Adaptability in Interconnected Ecosystems.

Our fourth design direction champions the natural world's dynamism and its visitors' diversity. This approach is dedicated to crafting experiences accessible to all, resonating with the adaptive and ever-evolving nature of ecosystems like the *Levadas* and the Laurisilva forest in times of climate change.

- **Design Potential h (DP-h): Incorporating Co-Adaptive and Resilient Designs**
  Participant data highlighted the dynamic, ever-changing nature of the environment, emphasizing weather variability (the desire of being "lucky with the weather", the "recommend[ation] to check the weather forecast, especially during the rainy season, as the terrain can be slippery and less safe", with one participant complaining that "the weather [had taken] a sudden turn, enveloping [then] in dense fog and rain"), trail erosion and variability (the "steep edges of the trail [that] made [one participant] nervous" or the "overgrown vegetation [that] obscured the trail,"), and habitat disturbances (the seemingly inevitable "environmental issues that concern [one participant], such as climate change [that results in] habitat destruction"), chiefly as participants navigated diverse ecosystems and expressed a need for trail infrastructure that could withstand natural forces while minimizing impact on the landscape (e.g., by keeping "well-maintained trails and flat ground."). Designing with natural heritage sites in the Anthropocene requires adaptive, resilient approaches that foster a co-adaptive relationship between humans and nature, under which embracing spontaneity and unpredictability may lead to designs that celebrate the unexpected and adapt to real-time data on climate patterns. Adaptive LGs might modify scenarios based on real-time environmental data, such as fog, wind, or rain, engaging visitors with the Laurisilva forest's dynamic nature while playing, which, combined with AI technologies, can create versatile, responsive experiences aligned with the environment's specificities.

- **Design Potential i (DP-i): Designing for Accessibility and Inclusivity While Cultivating Spaces of Belonging**
  The diversity of participants, each with unique abilities and backgrounds, emphasized the need for inclusive and accessible trail experiences (highlighting the trails that are "very accessible [...] for most people", the "higher level of difficulty" in other *Levadas*, for which the "difficulty rating is difficult", the *Levadas* that "in terms of difficulty, [one participant] found [...] to be intermediate", "the Levada[s that] present some difficulties along the way [and] therefore [one other participant] would not recommend [...] to everyone", the need to "preserve and protect these natural treasures, ensuring that they are accessible and enjoyable for all"), with individuals of various ages and physical abilities enjoying the Levada walks, often overcoming challenges to access natural spaces (while recognizing "[these] experience[s as] more challenging and motivating", the "more challenging

sections, with steep climbs and narrow paths" or the *Levadas* that are "a little more challenging in certain sections [yet remain] accessible to most people in good physical condition and willing to explore nature"). Accordingly, digital designs should focus on creating accessible spaces within the *Levadas* network, ensuring everyone feels welcome and part of nature — e.g., games with accessibility modes could cater to a diverse range of abilities, with multi-lingual or nonverbal storytelling celebrating the cultural diversity of Madeira's visitors while fostering an inclusive community of nature enthusiasts.

5 DISCUSSION

As the tourism industry continues to flourish, niche destinations are at risk. However, it is important that the growth of the travel and tourism sector continues in Madeira, as this industry generates robust revenues for this region [38], representing about 25 to 30% of regional PIB. This growth in tourism investment and development should nonetheless take place in an open and sustainable manner [28, 98]. As has been pointed out by others, ecological applications of cross-reality technologies are not yet widely researched or applied, leaving potential to be realized [91]. As such, the authors believe that it is essential to provide inspiration for design directions for the further protection and restoration of nature, habitats, and biodiversity in such niche and biodiversity-rich destinations.

In the rest of this section, we articulate four main points of discussion that emerged from our findings:

5.1 Locative game potentials

Our situated and embodied engagement within nature revealed design directions that can enrich heritage experiences and support their conservation. They shed light on caring aspects and directed our attention towards moments where technology could be implemented as less utilitarian but positively impact the environment. By articulating these felt and observed experiences as design potentials, we contribute to the discussion on locative media design interventions in the wild to care ever more for nature, to connect with it, and to become one with nature [93].

In further developing and implementing our proposed design directions and potentials, we must be mindful of their sensory limitations in making more-than-human realities "look and feel 'like the real thing'" while keeping in mind "how mediated interactions with wildlife may come to shape the future of our planet and our connection with it" [84]. Inasmuch as work has shown that the very experience of e.g., embodying animals within an immersive virtual environment potentiates one's involvement with nature, we should not lose track of the value of fully embodied and direct contact with nature [1]. If not alert to these possibilities, one might end up contributing to the 'environmental generational amnesia' that would inevitably result from subsequent generations fully replacing the experience of nature with technology-mediated interactions [53].

The previously identified tensions and design opportunities presented by LGs, as players co-author their playful narrative, are varied — e.g., the need for, given their implied geographic dynamics, LG to foster higher motivation in players or a sense of closure and reward within a story that is geographically dispersed [33]. When visiting heritage locations, aside from imparting knowledge to visitors, LGs may facilitate the renewal or development of relationships with places, but this success is dependent on "the balance of attention between the virtual and real (the story and the place)" [67]. All these elements present tensions that must be considered when implementing LGs for nature engagement. Many of these issues may be solved by designing LGs that do not compromise the players' attention and potential immersion in a space by not requiring the player to look at a screen while walking in the physical location with which the LG is contingent [57].

These early ideas and directions shared here (Fig. 1) are but starting points for caring technologies and LGs, and highlight the value of developing technological solutions in the wild, complementing direct contact with nature with added layers of technologically-mediated content and meaning.

5.2 Understanding the role of technology — or its absence — in natural environments

Moreover, these proposals and shared experiences also illuminate the space where designs should be careful or should not go, addressing the ongoing debate within HCI regarding technology's role in natural environments: balancing the enhancement of outdoor experiences against the potential for diminished immersion [96]. Considering the delicate balance of these ecosystems, we became aware of creating interventions that not only lead to the visit of such places, but also warn about it over exploitation and how not visiting, or visiting as indicated, might be an act of care and conservation in itself.

Following the suggestions put forward by Dorward et al. for "well-implemented AR games" (building on Pokémon Go's potential to increase engagement with real-world nature), we recognize the possibility of reaching numerous and varied publics with AR technologies such as LG, yet acknowledge the compromised needed between true immersion in nature and the simultaneous utilization of technology in nature [30]. As the necessity of the application of non-anthropocentric approaches to human-centered design is recognized, and concerns with care are placed center stage in the interaction design space, we will come ever closer to living truly collaborative relationships with our more-than-human planetary companions [19, 62]. Along these lines, we are committed to extending the reach of stories and lessons through alternative platforms such as off-site digital media, museum installations, or educational centers.

This approach not only ensures that a broader audience can connect with, but learn and benefit from, Madeira's natural and cultural heritage, yet underscores our commitment to a thoughtful and responsible engagement with technology. We thus ensure that our interventions are sustainable and mindful of the ecological sanctity of the site, nurturing a culture of empathy while cultivating a deep, caring relationship between individuals and the natural world.

5.3 Relational connections and multispecies interactions

The research underscores the significance of fostering multispecies interactions and a profound sense of belonging within the *Levadas*' ecosystem, urging interaction designers to approach their work with empathy and a deep respect for all life forms. This aligns with the ethos of Anthropocene feminist care and the human biophilic drive to connect with nature [116], which emphasize relational and contextual engagements with the environment, advocating for interactions and technologies that bolster our connection to the natural world without compromising its sanctity.

When one posits the human against the posthuman in LG design, one must be mindful of questions ranging from the experience to the nature of the relationship between player and narrative [7]. This fluidity and the liminal space it opens between player and narrative, in the empathy that it may afford, may very well play in favor of conservation, providing opportunities for successful nature engagement as we propose with our design potentials.

As Key et al. remind us, "researchers have turned to care ethics as a strategy to explicate and challenge dominant anthropocentric forces from design. Care as a feminist practice is about attending to what, how, and when things get caring attention and come to matter and what, how, and when things don't" [54].

In summary, our study highlights how, while the essence of the Levada experience is rooted in the unique biodiversity and cultural narratives of Madeira, the implementation of potential interactive experiences is not confined to the geographical boundaries of the site. Considering the delicate balance of these ecosystems, we are committed to extending the reach of stories and lessons through alternative platforms. This approach ensures that a broader audience can connect with and learn from Madeira's natural and cultural heritage.

Our study ultimately paints a suggestive future for locative interventions in natural heritage settings, calling for a shift towards design approaches that are empathetic, inclusive, and ecologically integrated, celebrating the interconnectedness of humans, technology, and nature. By adopting these principles, designers can craft locative HCI narratives that entertain and foster a deeper sense of connection, appreciation, and stewardship for the natural world and its myriad inhabitants, as exemplified by the *Levadas* of Madeira Island.

6 CONCLUSION

In this article the authors report on the findings from a study of the potentials for engagement with the natural heritage of the Madeira UNESCO heritage sites of the Levada walks, highlighting the role of locative gaming and HCI. Delving into the realm of posthumanist HCI, this study invites practitioners and scholars to move beyond human-centered design paradigms and embrace a more inclusive and caring approach to natural heritage that recognizes the complex interplay of humans and non-human actors. In line, the playful potentials here identified underscore the opportunity to design locative technologies that are engaging and imbue players with a sense of empathy and responsibility towards conservation, while keeping a focus on the challenge of balancing conservation needs with the demands of tourism. Results from the study demonstrate how a holistic understanding of visitor experiences can inspire the design of interactive technologies that foster meaningful and sustainable interactions with the natural world. In doing so, we point at potentials through which the HCI community may cultivate a more harmonious, beyond utilitarian relationship with nature — one that honors our shared history and mutual dependence, enriching human-nature interactions while guiding us towards a more sustainable and mindful engagement with the world around us.

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REFERENCES

[1] Sun Joo Grace Ahn, Joshua Bostick, Elise Ogle, Kristine L. Nowak, Kara T. McGillicuddy, and Jeremy N. Bailenson. 2016. Experiencing Nature: Embodying Animals in Immersive Virtual Environments Increases Inclusion of Nature in Self and Involvement With Nature: EMBODYING ANIMALS IN IMMERSIVE VIRTUAL ENVIRONMENTS. *Journal of Computer-Mediated Communication* 21, 6 (Nov. 2016), 399–419. https://doi.org/10.1111/jcc4.12173

[2] Paula Alavesa, Minna Pakanen, Timo Ojala, Matti Pouke, Hannu Kukka, Alexander Samodelkin, Alexander Voroshilov, and Mohamed Abdellatif. 2020. Embedding virtual environments into the physical world: memorability and copresence in the context of pervasive location-based games. *Multimedia Tools and Applications* 79, 5-6 (Feb. 2020), 3285–3309. https://doi.org/10.1007/s11042-018-7077-z

[3] Ferran Altarriba Bertran, Oğuz 'Oz Buruk, Velvet Spors, and Juho Hamari. 2023. Playful Inspiration for a New Wave of Joyful Forest Technology. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference*. ACM, Pittsburgh PA USA, 1886–1903. https://doi.org/10.1145/3563657.3596015

[4] Thomas Beery, Anton Stahl Olafsson, Sandra Gentin, Megan Maurer, Sanna Stålhammar, Christian Albert, Claudia Bieling, Arjen Buijs, Nora Fagerholm, Maria Garcia-Martin, Tobias Plieninger, and Christopher M. Raymond. 2023. Disconnection from nature: Expanding our understanding of human–nature relations. *People and Nature* 5, 2 (April 2023), 470–488. https://doi.org/10.1002/pan3.10451

[5] Marc G. Berman, Ethan Kross, Katherine M. Krpan, Mary K. Askren, Aleah Burson, Patricia J. Deldin, Stephen Kaplan, Lindsey Sherdell, Ian H. Gotlib, and John Jonides. 2012. Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders* 140, 3 (Nov. 2012), 300–305. https://doi.org/10.1016/j.jad.2012.03.012

[6] Gustavo Blanco-Wells. 2021. Ecologies of Repair: A Post-human Approach to Other-Than-Human Natures. *Frontiers in Psychology* 12 (April 2021), 633737. https://doi.org/10.3389/fpsyg.2021.633737

[7] Jonathan Boulter. 2015. *Parables of the posthuman: digital realities, gaming, and the player experience*. Wayne State University Press, Detroit, Michigan. OCLC: ocn907131772.

[8] Rosi Braidotti. 2013. Posthuman Humanities. *European Educational Research Journal* 12, 1 (March 2013), 1–19. https://doi.org/10.2304/eerj.2013.12.1.1

[9] Rosi Braidotti and Simone Bignall. 2019. *Posthuman ecologies: complexity and process after Deleuze*. Rowman & Littlefield International, London New York (N.Y.).

[10] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2 (Jan. 2006), 77–101. https://doi.org/10.1191/1478088706qp063oa

[11] Kate Brelje and Philosophy Documentation Center. 2023. More than Humans: A Case for Inclusion of Non-human Persons in Care Ethics. *Essays in Philosophy* 24, 1 (2023), 86–101. https://doi.org/10.5840/eip202352416

[12] Ben S. Bunting, Jacob Hughes, and Tim Hetland. 2012. The Player as Author: Exploring the Effects of Mobile Gaming and the Location-Aware Interface on Storytelling. *Future Internet* 4, 1 (Feb. 2012), 142–160. https://doi.org/10.3390/fi4010142

[13] Denis Byrne and Gro Birgit Ween. 2015. Bridging Cultural and Natural Heritage. In *Global Heritage: A Reader*. 94–111.

[14] Vanessa Cesário. 2019. Guidelines for Combining Storytelling and Gamification: Which Features Would Teenagers Desire to Have a More Enjoyable Museum Experience?. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, Glasgow Scotland Uk, 1–6. https://doi.org/10.1145/3290607.3308462

[15] Susan Clayton, Agathe Colléony, Pauline Conversy, Etienne Maclouf, Léo Martin, Ana-Cristina Torres, Minh-Xuan Truong, and Anne-Caroline Prévot. 2017. Transformation of Experience: Toward a New Relationship with Nature. *Conservation Letters* 10, 5 (Sept. 2017), 645–651. https://doi.org/10.1111/conl.12337

[16] Alexandra Coghlan and Lewis Carter. 2020. Serious games as interpretive tools in complex natural tourist attractions. *Journal of Hospitality and Tourism Management* 42 (March 2020), 258–265. https://doi.org/10.1016/j.jhtm.2020.01.010

[17] Carol Cohn. 2006. Motives and methods: using multi-sited ethnography to study US national security discourses. In *Feminist Methodologies for International Relations* (1 ed.), Brooke A. Ackerly, Maria Stern, and Jacqui True (Eds.). Cambridge University Press, 91–107. https://doi.org/10.1017/CBO9780511617690.007

[18] Aykut Coskun, Nazli Cila, Iohanna Nicenboim, Christopher Frauenberger, Ron Wakkary, Marc Hassenzahl, Clara Mancini, Elisa Giaccardi, and Laura Forlano. 2022. More-than-human Concepts, Methodologies, and Practices in HCI. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts*. ACM, New Orleans LA USA, 1–5. https://doi.org/10.1145/3491101.3516503

[19] Paul Coulton and Joseph Galen Lindley. 2019. More-Than Human Centred Design: Considering Other Things. *The Design Journal* 22, 4 (July 2019), 463–481. https://doi.org/10.1080/14606925.2019.1614320

[20] Paul J. Crutzen and Eugene F. Stoermer. 2017. "The 'Anthropocene"' (2000). In *The Future of Nature*, Libby Robin, Sverker Sörlin, and Paul Warde (Eds.). Yale University Press, 479–490. https://doi.org/10.12987/9780300188479-041

[21] Shaveta Dargan, Shally Bansal, Munish Kumar, Ajay Mittal, and Krishan Kumar. 2023. Augmented Reality: A Comprehensive Review. *Archives of Computational Methods in Engineering* 30, 2 (March 2023), 1057–1080. https://doi.org/10.1007/s11831-022-09831-7

[22] N. Davies, K. Cheverst, K. Mitchell, and A. Efrat. 2001. Using and determining location in a context-sensitive tour guide. *Computer* 34, 8 (Aug. 2001), 35–41. https://doi.org/10.1109/2.940011

[23] Y.A.W. De Kort, A.L. Meijnders, A.A.G. Sponselee, and W.A. IJsselsteijn. 2006. What's wrong with virtual trees? Restoring from stress in a mediated environment. *Journal of Environmental Psychology* 26, 4 (Dec. 2006), 309–320. https://doi.org/10.1016/j.jenvp.2006.09.001

[24] Shruti Desai and Harriet Smith. 2018. Kinship across Species: Learning to Care for Nonhuman Others. *Feminist Review* 118, 1 (April 2018), 41–60. https://doi.org/10.1057/s41305-018-0104-0

[25] Mara Dionisio, Mafalda Mendes, Marc Fernandez, Valentina Nisi, and Nuno Nunes. 2022. Aqua: Leveraging Citizen Science to Enhance Whale-Watching Activities and Promote Marine-Biodiversity Awareness. *Sustainability* 14, 21 (Oct. 2022), 14203. https://doi.org/10.3390/su142114203

[26] Mara Dionisio and Valentina Nisi. 2021. Leveraging Transmedia storytelling to engage tourists in the understanding of the destination's local heritage. *Multimedia Tools and Applications* 80, 26-27 (Nov. 2021), 34813–34841. https://doi.org/10.1007/s11042-021-10949-2

[27] Mara Dionisio, Valentina Nisi, Nuno Nunes, and Paulo Bala. 2016. Transmedia Storytelling for Exposing Natural Capital and Promoting Ecotourism. In *Interactive Storytelling*, Frank Nack and Andrew S. Gordon (Eds.). Vol. 10045. Springer International Publishing, Cham, 351–362. https://doi.org/10.1007/978-3-319-48279-8_31 Series Title: Lecture Notes in Computer Science.

[28] Mara Dionisio, Cláudia Silva, and Valentina Nisi. 2019. Fostering Interaction Between Locals and Visitors by Designing a Community-Based Tourism Platform on a Touristic Island. In *Human-Computer Interaction – INTERACT 2019*, David Lamas, Fernando Loizides, Lennart Nacke, Helen Petrie, Marco Winckler, and Panayiotis Zaphiris (Eds.). Vol. 11747. Springer International Publishing, Cham, 768–787. https://doi.org/10.1007/978-3-030-29384-0_46 Series Title: Lecture Notes in Computer Science.

[29] Carl DiSalvo, Phoebe Sengers, and Hrönn Brynjarsdóttir. 2010. Mapping the landscape of sustainable HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, Atlanta Georgia USA, 1975–1984. https://doi.org/10.1145/1753326.1753625

[30] Leejiah J. Dorward, John C. Mittermeier, Chris Sandbrook, and Fiona Spooner. 2017. Pokémon Go: Benefits, Costs, and Lessons for the Conservation Movement. *Conservation Letters* 10, 1 (Jan. 2017), 160–165. https://doi.org/10.1111/conl.12326

[31] John Dunham. 2021. Location Based Games and the People Who Play Them. In *Extended Abstracts of the 2021 Annual Symposium on Computer-Human Interaction in Play*. ACM, Virtual Event Austria, 394–396. https://doi.org/10.1145/3450337.3483514

[32] Matilda Eve Dunn, Gautam Shah, and Diogo Veríssimo. 2021. Stepping into the Wildeverse: Evaluating the impact of augmented reality mobile gaming on pro-conservation behaviours. *People and Nature* 3, 6 (Dec. 2021), 1205–1217. https://doi.org/10.1002/pan3.10273

[33] Jason Farman (Ed.). 2014. *The mobile story: narrative practices with locative technologies*. Routledge, New York.

[34] Melanie Feinberg, Sarah Fox, Jean Hardy, Stephanie Steinhardt, and Palashi Vaghela. 2019. At the Intersection of Culture and Method: Designing Feminist Action. In *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion*. ACM, San Diego CA USA, 365–368. https://doi.org/10.1145/3301019.3319993

[35] Filipa Fernandes. 2010. A cultura da água: da patrimonialização das levadas da Madeira à oferta turística. *PASOS Revista de turismo y patrimonio cultural* 8, 4 (2010). https://doi.org/10.25145/j.pasos.2010.08.046

[36] Filipa Fernandes. 2016. Built heritage and flash floods: hiking trails and tourism on Madeira Island. *Journal of Heritage Tourism* 11, 1 (Jan. 2016), 88–95. https://doi.org/10.1080/1743873X.2015.1082574

[37] Marta Ferreira, Valentina Nisi, and Nuno Nunes. 2023. Interactions with Climate Change: a Data Humanism Design Approach. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference*. ACM, Pittsburgh PA USA, 1325–1338. https://doi.org/10.1145/3563657.3596003

[38] Center for Responsible Travel. 2015. *The Case for Responsible Travel: Trends & Statistics 2015*. Technical Report. http://www.responsibletravel.org/resources/documents/2015%20Trends%20&%20Statistics_Final.pdf

[39] Christopher Frauenberger. 2020. Entanglement HCI The Next Wave? *ACM Transactions on Computer-Human Interaction* 27, 1 (Feb. 2020), 1–27. https://doi.org/10.1145/3364998

[40] Christina Fredengren. 2021. Nature:Cultures – Heritage, Sustainability and Feminist Posthumanism. *Current Swedish Archaeology* 23, 1 (June 2021), 109–130. https://doi.org/10.37718/CSA.2015.09

[41] Pasi Fränti and Nancy Fazal. 2023. Design Principles for Content Creation in Location-Based Games. *ACM Transactions on Multimedia Computing, Communications, and Applications* 19, 5s (Oct. 2023), 1–30. https://doi.org/10.1145/3583689

[42] Kathleen Fuegen and Kimberly H. Breitenbecher. 2018. Walking and Being Outdoors in Nature Increase Positive Affect and Energy. *Ecopsychology* 10, 1 (March 2018), 14–25. https://doi.org/10.1089/eco.2017.0036

[43] Bill Gaver, Tony Dunne, and Elena Pacenti. 1999. Design: Cultural probes. *Interactions* 6, 1 (Jan. 1999), 21–29. https://doi.org/10.1145/291224.291235

[44] Kristin Hanks, William Odom, David Roedl, and Eli Blevis. 2008. Sustainable millennials: attitudes towards sustainability and the material effects of interactive technologies. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, Florence Italy, 333–342. https://doi.org/10.1145/1357054.1357111

[45] Donna Haraway. 1991. A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century. In *Simians, Cyborgs and Women: The Reinvention of Nature*. Routledge.

[46] Donna Haraway. 1997. Situated Knowledges: the Science Question in Feminism and the Privilege of Partial Perspective. In *Space, Gender, Knowledge: Feminist Readings*. Routledge.

[47] Donna Haraway. 2008. Companion species, mis-recognition, and queer worlding. In *Queering the non/human*. xxiii–xxxvi.

[48] Donna Haraway, Noboru Ishikawa, Scott F. Gilbert, Kenneth Olwig, Anna L. Tsing, and Nils Bubandt. 2016. Anthropologists Are Talking – About the Anthropocene. *Ethnos* 81, 3 (May 2016), 535–564. https://doi.org/10.1080/00141844.2015.1105838

[49] Karey Helms and Ylva Fernaeus. 2021. Troubling Care: Four Orientations for Wickedness in Design. In *Designing Interactive Systems Conference 2021*. ACM, Virtual Event USA, 789–801. https://doi.org/10.1145/3461778.3462025

[50] B Humberstone, H Prince, and L Mansfield. 2017. The environment, physical activity, recreation and the outdoors. In *Routledge Handbook of Physical Activity Policy and Practice*. Routledge, 209–223.

[51] Alessandro Ianniello, Alessia Romani, and Francesca Casnati. 2022. Technology toward more-than-human symbiosis: Critical reflections from the design perspective. In *Proceedings of the 25th International Academic Mindtrek Conference*. ACM, Tampere Finland, 158–166. https://doi.org/10.1145/3569219.3569379

[52] Juliane Jarke and Susanne Maaß. 2018. Probes as Participatory Design Practice. *i-com* 17, 2 (Aug. 2018), 99–102. https://doi.org/10.1515/icom-2018-0026

[53] Peter H. Kahn, Rachel L. Severson, and Jolina H. Ruckert. 2009. The Human Relation With Nature and Technological Nature. *Current Directions in Psychological Science* 18, 1 (Feb. 2009), 37–42. https://doi.org/10.1111/j.1467-8721.2009.01602.x

[54] Cayla Key, Cally Gatehouse, and Nick Taylor. 2022. Feminist Care in the Anthropocene: Packing and Unpacking Tensions in Posthumanist HCI. In *Designing Interactive Systems Conference*. ACM, Virtual Event Australia, 677–692. https://doi.org/10.1145/3532106.3533540

[55] Yasuhiro Kotera, Melinda Lyons, Katia Correa Vione, and Briony Norton. 2021. Effect of Nature Walks on Depression and Anxiety: A Systematic Review. *Sustainability* 13, 7 (April 2021), 4015. https://doi.org/10.3390/su13074015

[56] Annakaisa Kultima and Alyea Sandovar. 2016. Game design values. In *Proceedings of the 20th International Academic Mindtrek Conference*. ACM, Tampere Finland, 350–357. https://doi.org/10.1145/2994310.2994362

[57] Samuli Laato, Daniel Fernández Galeote, Ferran Altarriba Bertran, and Juho Hamari. 2022. Balancing the Augmented Experience: Design Tensions in the Location-based Game Pikmin Bloom. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts*. ACM, New Orleans LA USA, 1–7. https://doi.org/10.1145/3491101.3519785

[58] Samuli Laato, Daniel Fernández Galeote, Ferran Altarriba Bertran, Konstantinos Papangelis, and Juho Hamari. 2023. How Location-Based Games Incentivize

Moving About: A Study in the Context of Nature-Going. *Proceedings of the ACM on Human-Computer Interaction* 7, CHI PLAY (Sept. 2023), 642–664. https://doi.org/10.1145/3611044

[59] Bruno Latour. 1994. *We have never been modern* (3. print. ed.). Harvard Univ. Press, Cambridge, Mass.

[60] Jung Eun Lee, Nan Zeng, Yoonsin Oh, Daehyoung Lee, and Zan Gao. 2021. Effects of Pokémon GO on Physical Activity and Psychological and Social Outcomes: A Systematic Review. *Journal of Clinical Medicine* 10, 9 (April 2021), 1860. https://doi.org/10.3390/jcm10091860

[61] Jingyi Li, Yong Ma, Puzhen Li, and Andreas Butz. 2021. A Journey Through Nature: Exploring Virtual Restorative Environments as a Means to Relax in Confined Spaces. In *Creativity and Cognition*. ACM, Virtual Event Italy, 1–9. https://doi.org/10.1145/3450741.3465248

[62] Ann Light. 2022. Ecologies of subversion: troubling interaction design for climate care. *Interactions* 29, 1 (Jan. 2022), 34–38. https://doi.org/10.1145/3501301

[63] Anne Marike Lokhorst, Céline Hoon, Rob Le Rutte, and Geert De Snoo. 2014. There is an I in nature: The crucial role of the self in nature conservation. *Land Use Policy* 39 (July 2014), 121–126. https://doi.org/10.1016/j.landusepol.2014.03.005

[64] Amari Low, Jane Turner, and Marcus Foth. 2022. Pla(y)cemaking With Care: Locative Mobile Games as Agents of Place Cultivation. In *Proceedings of the 25th International Academic Mindtrek Conference*. ACM, Tampere Finland, 135–146. https://doi.org/10.1145/3569219.3569311

[65] Kate Lund, Mark Lochrie, and Paul Coulton. 2010. Enabling emergent behaviour in location based games. In *Proceedings of the 14th International Academic MindTrek Conference: Envisioning Future Media Environments*. ACM, Tampere Finland, 78–85. https://doi.org/10.1145/1930488.1930505

[66] Sophie McDonald, David Kirk, and Nick Bryan-Kinns. 2015. Nature Bot: Experiencing Nature in the Built Environment. In *Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition*. ACM, Glasgow United Kingdom, 173–176. https://doi.org/10.1145/2757226.2764547

[67] David E. Millard, Heather Packer, Yvonne Howard, and Charlie Hargood. 2020. The Balance of Attention: The Challenges of Creating Locative Cultural Storytelling Experiences. *Journal on Computing and Cultural Heritage* 13, 4 (Dec. 2020), 1–24. https://doi.org/10.1145/3404195

[68] Markus Montola, Jaakko Stenros, and Annika Wærn. 2009. *Pervasive games: theory and design*. Morgan Kaufmann Publishers, Burlington, MA.

[69] Luís Mota, Mara Franco, and Rossana Santos. 2021. Island tourism carrying capacity in the UNESCO Site Laurisilva of Madeira. *Island Studies Journal* 16, 2 (2021), 255–269. https://doi.org/10.24043/isj.143

[70] Florian Mueller, Sophie Stellmach, Saul Greenberg, Andreas Dippon, Susanne Boll, Jayden Garner, Rohit Khot, Amani Naseem, and David Altimira. 2014. Proxemics play: understanding proxemics for designing digital play experiences. In *Proceedings of the 2014 conference on Designing interactive systems*. ACM, Vancouver BC Canada, 533–542. https://doi.org/10.1145/2598510.2598532

[71] Manasee Narvilkar, Josiah Mangiameli, Adriana Alvarado Garcia, Azra Ismail, Daniel Schiff, Danielle Schechter, Jordan Chen, Karthik Bhat, Marisol Wong-Villacres, Anusha Vasudeva, Aparna Ramesh, Michaelanne Dye, Naveena Karusala, Pragati Singh, Savanthi Murthy, Shubhangi Gupta, Udaya Lakshmi, and Neha Kumar. 2019. Bringing Shades of Feminism To Human-Centered Computing. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, Glasgow Scotland Uk, 1–12. https://doi.org/10.1145/3290607.3310419

[72] Anne Naukkarinen, Jenna Sutela, Andrea Botero, and Kari-Hans Kommonen. 2009. Designing locative media for creative misuse: learning from urban intervention. *Proceedings of the 13th International Academic Mindtrek Conference* (2009).

[73] Velvet Nelson. 2015. Tourist Identities in Narratives of Unexpected Adventure in Madeira. *International Journal of Tourism Research* 17, 6 (Nov. 2015), 537–544. https://doi.org/10.1002/jtr.2018

[74] Carman Neustaedter, Anthony Tang, and Judge K. Tejinder. 2010. The role of community and groupware in geocache creation and maintenance. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, Atlanta Georgia USA, 1757–1766. https://doi.org/10.1145/1753326.1753590

[75] Valentina Nisi, Catia Prandi, and Nuno Jardim Nunes. 2020. Towards Eco-Centric Interaction: Urban Playful Interventions in the Anthropocene. In *Making Smart Cities More Playable*, Anton Nijholt (Ed.). Springer Singapore, Singapore, 235–257. https://doi.org/10.1007/978-981-13-9765-3_11 Series Title: Gaming Media and Social Effects.

[76] Nuno Jardim Nunes, Marko Radeta, and Valentina Nisi. 2020. Enhancing Whale Watching with Mobile Apps and Streaming Passive Acoustics. In *Entertainment Computing – ICEC 2020*, Nuno J. Nunes, Lizhuang Ma, Meili Wang, Nuno Correia, and Zhigeng Pan (Eds.). Vol. 12523. Springer International Publishing, Cham, 205–222. https://doi.org/10.1007/978-3-030-65736-9_18 Series Title: Lecture Notes in Computer Science.

[77] Kenton O'Hara, Tim Kindberg, Maxine Glancy, Luciana Baptista, Byju Sukumaran, Gil Kahana, and Julie Rowbotham. 2007. Social practices in location-based collecting. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, San Jose California USA, 1225–1234. https://doi.org/10.1145/1240624.1240810

[78] Paulo Oliveira and Pedro Telhado Pereira. 2008. Who Values What in a Tourism Destination? The Case of Madeira Island. *Tourism Economics* 14, 1 (March 2008), 155–168. https://doi.org/10.5367/000000008783554758

[79] Jessica L. Oliver, Margot Brereton, David M. Watson, and Paul Roe. 2019. Listening to Save Wildlife: Lessons Learnt from Use of Acoustic Technology by a Species Recovery Team. In *Proceedings of the 2019 on Designing Interactive Systems Conference*. ACM, San Diego CA USA, 1335–1348. https://doi.org/10.1145/3322276.3322360

[80] Konstantinos Papangelis, Melvin Metzger, Yiyeng Sheng, Hai-Ning Liang, Alan Chamberlain, and Ting Cao. 2017. Conquering the City: Understanding perceptions of Mobility and Human Territoriality in Location-based Mobile Games. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 1, 3 (Sept. 2017), 1–24. https://doi.org/10.1145/3130955

[81] Thymio Papayannis and Peter Howard. 2007. Editorial: Nature as Heritage. *International Journal of Heritage Studies* 13, 4-5 (July 2007), 298–307. https://doi.org/10.1080/13527250701350835

[82] Natasa Paterson, Gavin Kearney, Katsiaryna Naliuka, Tara Carrigy, Mads Haahr, and Fionnuala Conway. 2013. Viking Ghost Hunt: creating engaging sound design for location-aware applications. *International Journal of Arts and Technology* 6, 1 (2013), 61. https://doi.org/10.1504/IJART.2013.050692

[83] Catlin Pidel and Philipp Ackermann. 2020. Collaboration in Virtual and Augmented Reality: A Systematic Overview. In *Augmented Reality, Virtual Reality, and Computer Graphics*, Lucio Tommaso De Paolis and Patrick Bourdot (Eds.). Vol. 12242. Springer International Publishing, Cham, 141–156. https://doi.org/10.1007/978-3-030-58465-8_10 Series Title: Lecture Notes in Computer Science.

[84] Daniel Pimentel. 2021. The Peril and Potential of XR-based Interactions with Wildlife. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–9. https://doi.org/10.1145/3411763.3450378

[85] Fabio Pittarello. 2011. Designing a Context-Aware Architecture for Emotionally Engaging Mobile Storytelling. In *Human-Computer Interaction – INTERACT 2011*, David Hutchison, Takeo Kanade, Josef Kittler, Jon M. Kleinberg, Friedemann Mattern, John C. Mitchell, Moni Naor, Oscar Nierstrasz, C. Pandu Rangan, Bernhard Steffen, Madhu Sudan, Demetri Terzopoulos, Doug Tygar, Moshe Y. Vardi, Gerhard Weikum, Pedro Campos, Nicholas Graham, Joaquim Jorge, Nuno Nunes, Philippe Palanque, and Marco Winckler (Eds.). Vol. 6946. Springer Berlin Heidelberg, Berlin, Heidelberg, 144–151. https://doi.org/10.1007/978-3-642-23774-4_14 Series Title: Lecture Notes in Computer Science.

[86] Catia Prandi, Valentina Nisi, Pedro Loureiro, and Nuno J. Nunes. 2020. Storytelling and remote-sensing playful interventions to foster biodiversity awareness. *International Journal of Arts and Technology* 12, 1 (2020), 39. https://doi.org/10.1504/IJART.2020.107680

[87] João Prudente, Helder Lopes, João Noite, Ana Rodrigues, Sara Vieira, Ricardo Alves, and Catarina Fernando. 2020. Hikes and Levadas in Madeira: Characterizing Visitors and their experience. *European Journal of Tourism, Hospitality and Recreation* 10, 2 (Dec. 2020), 154–164. https://doi.org/10.2478/ejthr-2020-0013

[88] Maria Puig De La Bellacasa. 2015. Making time for soil: Technoscientific futurity and the pace of care. *Social Studies of Science* 45, 5 (Oct. 2015), 691–716. https://doi.org/10.1177/0306312715599851

[89] María Puig de La Bellacasa. 2017. *Matters of care: speculative ethics in more than human worlds*. Number 41 in Posthumanities. University of Minnesota press, Minneapolis (Minn.).

[90] RM Pyle. 1993. *The thunder tree: lessons from an urban wildland*. Houghton Mifflin.

[91] Jason Rambach, Gergana Lilligreen, Alexander Schäfer, Ramya Bankanal, Alexander Wiebel, and Didier Stricker. 2021. A Survey on Applications of Augmented, Mixed and Virtual Reality for Nature and Environment. In *Virtual, Augmented and Mixed Reality*, Jessie Y. C. Chen and Gino Fragomeni (Eds.). Vol. 12770. Springer International Publishing, Cham, 653–675. https://doi.org/10.1007/978-3-030-77599-5_45 Series Title: Lecture Notes in Computer Science.

[92] Adrian Reetz, Deltcho Valtchanov, Michael Barnett-Cowan, Mark Hancock, and James R. Wallace. 2021. Nature vs. Stress: Investigating the Use of Biophilia in Non-Violent Exploration Games to Reduce Stress. *Proceedings of the ACM on Human-Computer Interaction* 5, CHI PLAY (Oct. 2021), 1–13. https://doi.org/10.1145/3474674

[93] Shannon Rodgers, Kellie Vella, Bernd Ploderer, and Margot Brereton. 2023. Nature Fictions: Designing for a Sustainable Future through Nature Relations. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference*. ACM, Pittsburgh PA USA, 1566–1580. https://doi.org/10.1145/3563657.3595981

[94] Richard M. Ryan, Netta Weinstein, Jessey Bernstein, Kirk Warren Brown, Louis Mistretta, and Marylène Gagné. 2010. Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology* 30, 2 (June 2010), 159–168. https://doi.org/10.1016/j.jenvp.2009.10.009

[95] Elena B. Sabinson and Keith Evan Green. 2023. A Walk in Nature: Exploring the Creative Potentials of a Generative Design Tool for Soft Robotic Surfaces that Foster a Connection with Nature.. In *Creativity and Cognition*. ACM, Virtual Event USA, 185–199. https://doi.org/10.1145/3591196.3593367

[96] Chris Sandbrook, William M. Adams, and Bruno Monteferri. 2015. Digital Games and Biodiversity Conservation. *Conservation Letters* 8, 2 (March 2015), 118–124. https://doi.org/10.1111/conl.12113

[97] Jihan Sherman. 2023. Black Feminist Technoscience: Sojourner Truth, Storytelling, and a Framework for Design. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference*. ACM, Pittsburgh PA USA, 978–986. https://doi.org/10.1145/3563657.3596105

[98] Claudia Silva, Ana Bettencourt, Mara Dionisio, Deborah Castro, Dina Dionisio, Duarte Teixeira, and Valentina Nisi. 2017. Há-Vita: A transmedia platform about Madeira's nature and culture. In *2017 Sustainable Internet and ICT for Sustainability (SustainIT)*. IEEE, Funchal, 1–2. https://doi.org/10.23919/SustainIT.2017.8379813

[99] Jorge Soares and Naidea Nunes. 2020. *Levada* walks and canyoning as mountain sport products in nature tourism. *European Journal of Tourism, Hospitality and Recreation* 10, 1 (May 2020), 41–55. https://doi.org/10.2478/ejthr-2020-0004

[100] Masashi Soga and Kevin J Gaston. 2016. Extinction of experience: the loss of human–nature interactions. *Frontiers in Ecology and the Environment* 14, 2 (March 2016), 94–101. https://doi.org/10.1002/fee.1225

[101] Masashi Soga and Kevin J. Gaston. 2020. The ecology of human–nature interactions. *Proceedings of the Royal Society B: Biological Sciences* 287, 1918 (Jan. 2020), 20191882. https://doi.org/10.1098/rspb.2019.1882

[102] Jaakko Stenros, Markus Montola, and Frans Mäyrä. 2007. Pervasive games in ludic society. In *Proceedings of the 2007 conference on Future Play - Future Play '07*. ACM Press, Toronto, Canada, 30. https://doi.org/10.1145/1328202.1328209

[103] Sonja Sudimac, Vera Sale, and Simone Kühn. 2022. How nature nurtures: Amygdala activity decreases as the result of a one-hour walk in nature. *Molecular Psychiatry* 27, 11 (Nov. 2022), 4446–4452. https://doi.org/10.1038/s41380-022-01720-6

[104] Marie Louise Juul Søndergaard, Marianela Ciolfi Felice, and Madeline Balaam. 2021. Designing Menstrual Technologies with Adolescents. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–14. https://doi.org/10.1145/3411764.3445471

[105] Cedric K. W. Tan and Hidayah Nurul-Asna. 2023. Serious games for environmental education. *Integrative Conservation* 2, 1 (March 2023), 19–42. https://doi.org/10.1002/inc3.18

[106] Dallen J. Timothy and Stephen W. Boyd. 2003. *Heritage tourism* (1st ed ed.). Prentice Hall, New York.

[107] Oscar Tomico, Ferran Altarriba, Svenja Keune, Oğuz Buruk, Danielle Wilde, and Ron Wakkary. 2023. Designerly ways of engaging with nature. In *26th International Academic Mindtrek Conference*. ACM, Tampere Finland, 309–312. https://doi.org/10.1145/3616961.3616993

[108] Minh-Xuan A. Truong and Susan Clayton. 2020. Technologically transformed experiences of nature: A challenge for environmental conservation? *Biological Conservation* 244 (April 2020), 108532. https://doi.org/10.1016/j.biocon.2020.108532

[109] Anna Lowenhaupt Tsing. 2021. *The mushroom at the end of the world: on the possibility of life in capitalist ruins* (new paperback printing ed.). Princeton University Press, Princeton Oxford.

[110] Jasmine B. Ulmer. 2017. Posthumanism as research methodology: inquiry in the Anthropocene. *International Journal of Qualitative Studies in Education* 30, 9 (Oct. 2017), 832–848. https://doi.org/10.1080/09518398.2017.1336806

[111] Kellie Vella, Michael Esteban, Bernd Ploderer, and Margot Brereton. 2022. Networked Gardens: Remediating Local Nature Data Through the Internet of Things. In *Designing Interactive Systems Conference*. ACM, Virtual Event Australia, 1597–1611. https://doi.org/10.1145/3532106.3533497

[112] Peter-Paul Verbeek. 2015. Beyond interaction: a short introduction to mediation theory. *Interactions* 22, 3 (April 2015), 26–31. https://doi.org/10.1145/2751314

[113] Valentina Vezzani, Susana Gonzaga, and Elisa Bertolotti. 2019. Atlantic Wonder. Exploring Nature and Design in Madeira island. *The Design Journal* 22, sup1 (April 2019), 1603–1617. https://doi.org/10.1080/14606925.2019.1594994

[114] Mark J. Weal, Don Cruickshank, Danius T. Michaelides, David E. Millard, David C. De Roure, Katherine Howland, and Geraldine Fitzpatrick. 2007. A Card Based Metaphor for Organising Pervasive Educational Experiences. In *Fifth Annual IEEE International Conference on Pervasive Computing and Communications Workshops (PerComW'07)*. IEEE, White Plains, NY, 165–170. https://doi.org/10.1109/PERCOMW.2007.3

[115] Sarah Webber, Ryan M. Kelly, Greg Wadley, and Wally Smith. 2023. Engaging with Nature through Technology: A Scoping Review of HCI Research. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. ACM, Hamburg Germany, 1–18. https://doi.org/10.1145/3544548.3581534

[116] Edward O. Wilson. 1994. *Biophilia: the human bond with other species*. Harvard Univ. Press, Cambridge, Mass.

[117] Isabelle D. Wolf, David B. Croft, and Ronda J. Green. 2019. Nature Conservation and Nature-Based Tourism: A Paradox? *Environments* 6, 9 (Sept. 2019), 104. https://doi.org/10.3390/environments6090104

[118] Isabelle D. Wolf and Teresa Wohlfart. 2014. Walking, hiking and running in parks: A multidisciplinary assessment of health and well-being benefits. *Landscape and Urban Planning* 130 (Oct. 2014), 89–103. https://doi.org/10.1016/j.landurbplan.2014.06.006

[119] Spyridon Xanthopoulos and Stelios Xinogalos. 2018. Opportunities and challenges of mobile location-based games in education: Exploring the integration of authoring and analytics tools. In *2018 IEEE Global Engineering Education Conference (EDUCON)*. IEEE, Tenerife, 1797–1805. https://doi.org/10.1109/EDUCON.2018.8363452

[120] Ningning Xu, Jiachen Liang, Kexiang Shuai, Yuwen Li, and Jiaqi Yan. 2023. HeritageSite AR: An Exploration Game for Quality Education and Sustainable Cultural Heritage. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*. ACM, Hamburg Germany, 1–8. https://doi.org/10.1145/3544549.3583837

[121] Andrea Zeffiro. 2012. A location of one's own: A genealogy of locative media. *Convergence: The International Journal of Research into New Media Technologies* 18, 3 (Aug. 2012), 249–266. https://doi.org/10.1177/1354856512441148

[122] Sena Çerçi, Marta E. Cecchinato, and John Vines. 2021. How Design Researchers Interpret Probes: Understanding the Critical Intentions of a Designerly Approach to Research. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–15. https://doi.org/10.1145/3411764.3445328