



## An Interdisciplinary Framework for Conservation Education: Bridging Science, Participatory Design and Management

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### Abstract

*This paper explores Parques Nacionales: Pasado, Presente y Futuro (National Parks: Past, Present, and Future), an interdisciplinary course at Universidad de los Andes, as a pioneering model for conservation education in Colombia. Rooted in the methodology of participatory design, the course challenges conventional conservation paradigms by integrating biological sciences, design, and management with community-driven innovation. Students engage in immersive fieldwork, collaborative mapping, and iterative prototyping, working alongside local communities to address socio-ecological dilemmas facing Colombia's National Protected Areas System. Drawing inspiration from the Parques Cómo Vamos initiative—an observatory involving nine organizations to monitor the state of national parks—the course leverages robust, data-driven monitoring and policy advocacy to ground its interventions in real-world challenges, such as deforestation, underfunding, and governance conflicts. The curriculum unfolds through seven iterative stages: contextual immersion, systems modeling, dilemma negotiation, future scenario co-creation, prototyping, funding strategizing, and multimodal storytelling. This approach foregrounds the plurality of knowledge systems, elevating human stakeholders' sketches and oral histories alongside quantitative data, and actively dismantles hierarchies between “expert” and “local” knowledge. Comparative analysis with global conservation programs highlights the course's unique contribution to participatory, equity-centered pedagogy. Student reflections and project outcomes demonstrate the transformative impact of this model in fostering trust, adaptability, and decolonization praxis. The paper argues that as biodiversity (and climate) crises intensify, such pluriversal cartography offers a vital blueprint for training conservationists capable of navigating complexity without sacrificing social justice. Ultimately, the course positions conservation education as an act of solidarity and co-creation, where maps become living dialogues and protected areas are reimagined as spaces of relational stewardship and innovation.*

**Keywords:** Interdisciplinary Conservation, co-teaching, Community Engagement, Participatory Design, Pluriversal Knowledge

### 1. Introduction: Cartographies of Conservation in Colombia

Colombia's conservation history is a palimpsest of conflicting visions—from the exclusionary “fortress conservation” models of the mid-20th century to the participatory frameworks enshrined in the 1991 Constitution [17]. This tension between ecological preservation and social equity forms the crucible for Parques Nacionales: Pasado, Presente y Futuro (National Parks: Past, Present and Future), a course which reimagines protected areas as living laboratories for interdisciplinary problem-solving.

A distinctive feature of this course is its co-teaching model, in which each cohort is guided by a team of professors representing biological sciences, management, and participatory design. This structure ensures that every class session and project benefits from the simultaneous presence and collaboration of experts with complementary disciplinary backgrounds. Rather than relegating interdisciplinary integration to occasional guest lectures or isolated modules, the course is co-designed and co-delivered by these three faculty members, who jointly plan, facilitate, and assess all learning activities. Such a model not only exposes students to diverse perspectives but also provides a living example of how disciplinary boundaries can be constructively negotiated in real time. Our teaching is informed by research on co-teaching, which demonstrates its significant benefits for



interdisciplinary education [31]. For instance, Burian and Apul [6] observe that co-teaching enhances student learning in sustainability by actively modeling cross-disciplinary dialogue and adaptive, collaborative problem-solving. Similarly, Barab and colleagues [3] show that courses led by faculty from multiple disciplines foster more authentic and engaged student participation, especially when addressing complex, “wicked” problems. Recent studies further indicate that students in co-taught environments experience higher engagement, a deeper synthesis of knowledge, and greater ability to apply concepts across different contexts [3][6]. This evidence supports our approach of integrating biological sciences, management, and participatory design professors in every cohort, ensuring that students benefit from a dynamic, dialogic, and truly interdisciplinary learning environment. In this course, the collaborative presence of professors from science, management, and design not only enriches the curriculum but also embodies the very interdisciplinarity and participatory rationale that the course seeks to instill in its students.

Central to this reimagining is social cartography, a methodology previously explored as a tool for democratizing design processes [19][21]. Unlike traditional mapping, social cartography prioritizes community narratives, translating intangible relationships between farmers and páramos, miners and jaguars, policymakers and indigenous leaders, into visual dialogues. The course operationalizes this approach, challenging students to abandon reductionist “problem-solving” in favor of grappling with socio-ecological dilemmas—complex, often contradictory scenarios where conservation goals intersect with human rights, economic survival, and cultural identity [13][15].

## **2. Theoretical and Methodological Foundations**

### ***2.1 Participatory Design and Social Innovation***

Seven iterative stages scaffold the course’s pedagogy, each informed by principles of participatory design and systems thinking. Participatory design, as articulated by Sanders [24] and Sanders & Stappers [25], moves beyond user-centered approaches to embrace co-creation, where stakeholders become active participants in the design process. This is echoed by Manzini & Coad [18], who argue that design for social innovation requires distributed agency and collective intelligence.

Critical design ethnography [3] and cultural probes [14] are employed to elicit community knowledge and foster dialogue. Design games [5] and participatory innovation [7] further support collaborative exploration and creative problem-solving. These methods are complemented by actor-network theory [8], which recognizes the agency of both human and non-human actors in shaping conservation outcomes.

### ***2.2. Systems Thinking and Socio-Ecological Frameworks***

Systems thinking, as articulated by Jones [16] and Ostrom [23], provides a framework for understanding protected areas as coupled human-natural systems. Ostrom’s institutional analysis framework is used to deconstruct governance structures, resource flows, and stakeholder relationships. Dilemma negotiation is inspired by Den Ouden’s [11] value framework, enabling students to identify and balance competing priorities such as economic development, biodiversity, and social justice.

The course’s iterative prototyping phase draws on principles of innovation as a learning process [4] and the need for ongoing adaptation in response to feedback and changing conditions [20]. Funding strategizing and multimodal storytelling further embed the projects in real-world contexts, aligning with De Francisco Vela et al.’s [10] work on co-creating microfinance models for conservation.

### ***2.3 Curriculum Structure: Seven Iterative Stages***

The curriculum structure of Parques Nacionales: Pasado, Presente y Futuro unfolds over a carefully designed sixteen-week period, a duration deliberately chosen to foster both depth and continuity in the learning process. This temporal extent is not incidental; rather, it is essential for enabling students to meaningfully iterate and integrate their evolving insights into the collaborative projects that anchor the course. The sixteen-week framework allows participants to move beyond superficial engagement, immersing themselves in the complexities of Colombia’s protected areas and the communities that inhabit them. Through successive cycles of contextual immersion, analysis,



prototyping, and reflection, students are afforded the time and space necessary to revisit assumptions, adapt strategies, and synthesize interdisciplinary knowledge. This iterative rhythm mirrors the adaptive, cyclical nature of socio-ecological systems themselves, encouraging learners to respond to feedback from both human and ecological stakeholders. In this way, the course's structure embodies its pedagogical philosophy: that transformative conservation education requires not only exposure to diverse perspectives and tools but also the sustained opportunity to enact, test, and refine these approaches in real-world contexts.

The following seven stages structure the course's progression, each building upon the last to guide students through a comprehensive, iterative process that enables them to integrate theory and practice while responding adaptively to the complexities encountered in their projects.

1. **Contextual Immersion:** Students conduct ethnographic fieldwork in protected areas such as Guasca's Páramo Grande, employing social cartography techniques to map stakeholder relationships. This phase echoes earlier work on community-led mapping in Bogotá's informal settlements, where hand-drawn sketches by residents revealed hidden power dynamics overlooked by satellite imagery [21].
2. **Systems Modeling:** Using Ostrom's institutional analysis framework [23], students deconstruct protected areas as coupled human-natural systems. For example, in the Laguna de Guatavita project, teams modeled silvopastoral corridors as nested systems balancing ranchers' livelihoods with Andean bear habitats [9][23].
3. **Dilemma Negotiation:** Inspired by Den Ouden's value framework [11], students identify competing priorities and interests (e.g., tourism revenue vs. indigenous land rights) and prototype solutions through participatory workshops [11].
4. **Future Scenarios:** Communities and students co-create visions of future realities, such as "Páramos as Water Factories," blending ancestral knowledge with speculative design [13].
5. **Iterative Prototyping:** Low-fidelity interventions—from augmented reality games to mycelium-based erosion barriers—are tested and refined through community feedback loops [25].
6. **Funding Strategizing:** Students align projects with green financing mechanisms, such as the IUCN's Lista Verde criteria, and explore models for sustainable resource management [2][30].
7. **Multimodal Storytelling:** Outcomes are communicated through documentaries, policy briefs, and printed books, ensuring diverse audiences engage with conservation narratives [19].

### **3. Case Study: Cercados entre Cerros – Cartographies of Conflict and Cohesion**

The Cercados entre Cerros project exemplifies the course's social cartography ethos. Focused on Guasca's páramo ecosystem, students collaborated with farmers, teachers, and the NGO Fundación Caminando por Nuestro Futuro to address soil degradation linked to unsustainable agriculture.

#### **3.1 Phase 1: Mapping Memory**

Initial fieldwork involved participatory sketch mapping, where farmers drew ancestral land-use practices onto transparent overlays of satellite images. This process, akin to earlier studies with street vendors in Bogotá, revealed that traditional crop rotation systems—abandoned during Colombia's armed conflict—had historically prevented erosion. Farmers' sketches became the basis for GIS models quantifying how reviving these practices could reduce sediment runoff [21].

#### **3.2 Phase 2: Dilemma Workshops**

Students then facilitated workshops using Den Ouden's value framework [11] to dissect conflicts at multiple levels. At the user level, farmers resisted reforestation due to pasture loss; at the ecosystem level, degraded soils threatened Bogotá's water supply; and at the societal level, urban populations demanded clean water without understanding rural trade-offs. Through role-playing exercises, students embodied stakeholders—a technique advocated to counteract design teams' tendency to oversimplify "problems" [21]. This led to prototyping agroforestry plots combining native tree species with high-value crops like goldenberry, addressing both ecological and economic needs.

#### **3.3 Phase 3: Prototyping Futures**

The final intervention was a school curriculum co-designed with teachers using augmented reality (AR) to gamify páramo conservation. Students created an AR app where virtual spectacled bears “rewarded” children for identifying invasive species, blending Indigenous storytelling with digital tools. This mirrors findings on using play as a bridge between technocratic and traditional knowledge systems [5][14].

### **3.4. Phase 4: Funding Strategy and Multi-Sectoral Partnerships**

The Cercados entre Cerros project developed a strong funding strategy by forming partnerships with organizations like Fundación Caminando por Nuestro Futuro and aligning with regional conservation priorities. These alliances provided technical support and access to critical ecosystem data, enhancing the project’s credibility with local government bodies such as the Secretaría de Educación de Cundinamarca. The team also pursued grants and microfinance opportunities, leveraging its interdisciplinary expertise. By aligning objectives with local and NGO sustainability goals, the project attracted diverse investment to support both its pilot phase and future expansion.

### **3.5 Project Definition and Communication**

The Cercados entre Cerros project’s success was grounded in a clear definition of objectives and a comprehensive communication strategy. The team articulated its central mandate as the development and implementation of a standardized educational protocol for páramo conservation in Guasca’s schools, directly addressing urgent regional challenges such as deforestation, water mismanagement, and biodiversity loss. Communication was prioritized at every stage, with regular meetings involving school administrators, teachers, and local leaders to ensure alignment between project goals and stakeholder expectations. Diverse channels—including participatory workshops, visually engaging materials, and interactive activities—were employed to foster a sense of ownership and relevance among students, educators, and the broader community. Systematic documentation and dissemination of project outcomes and methodologies to the Secretaría de Educación and other partners positioned Cercados entre Cerros as a replicable model for environmental education and conservation in similar socio-ecological contexts.

## **4. Comparative Analysis: Global Lessons, Local Innovations**

### **4.1 Stanford University: Field-Based Environmental Education**

Stanford’s School of Earth, Energy and Environmental Sciences offers a coterminal degree program that integrates disciplinary and interdisciplinary research, fieldwork, and hands-on learning [1]. The program prepares students for a wide range of environmental careers and emphasizes the importance of experiential, real-world learning by doing. Field trips and outdoor research are central, enabling students to develop critical thinking and scientific skills in authentic settings. Stanford’s philosophy—that “one of the most important ways to learn about the world is to go out and explore it”—closely aligns with the immersive fieldwork component of Parques Nacionales: Pasado, Presente y Futuro.

Moreover, this approach is strongly supported by recent research on sustainability education. Novy et al. [22] argue in “A Core Curriculum for Sustainability Leadership” that addressing today’s complex sustainability challenges requires not only interdisciplinary knowledge but also systems thinking, iterative design, and the cultivation of leadership identity and agency. Their study of Stanford’s Change Leadership for Sustainability Program demonstrates that field-based, participatory, and reflective pedagogies are essential for preparing students to lead change in complex social-environmental systems. The authors emphasize that effective sustainability education must go beyond technical skills, fostering the capacity for critical inquiry, collaborative problem-solving, and adaptive leadership. In this sense, our course at Universidad de los Andes stands firmly within a global movement toward sustainability education that is transformative, action-oriented, and deeply rooted in real-world engagement [22].

While Stanford’s program excels in scientific rigor and field-based learning, it is less explicit in its integration of participatory design and community co-creation. The focus is often on data collection and analysis, with less emphasis on the social cartography and stakeholder negotiation that are



central to our course. As one Stanford student reflected in a review of environmental education impact, “This program has changed the way I feel about school. Now I realize that I can pretty much do what anybody else can do. I have a better view of what I can be in the future” [1]. This highlights the transformative potential of environmental education but also points to the need for deeper engagement with local communities and knowledge systems.

#### **4.2 Yale University: Tropical Forest Landscapes Certificate**

Yale’s Tropical Forest Landscapes Certificate Program is a leading example of interdisciplinary conservation education [29]. The program includes core courses on ecological and social concepts, people and engagement, strategies for land use planning, and funding. A capstone project and an optional field course provide opportunities for practical application and stakeholder engagement. The program is designed to be flexible and accessible, with online coursework and a global network of participants.

Yale’s program stands out for its emphasis on interdisciplinary learning, stakeholder engagement, and practical skills. Participant feedback highlights the value of the program in building networks, developing project management skills, and applying knowledge in real-world settings. For example, one graduate noted, “Through this program, I gained the knowledge I needed to parlay my career in commercial arboriculture into a Community Forestry model. I’ve been able to incorporate many of the program’s concepts already, including stakeholder mapping and stock and yield analysis, into my Community Forestry planning.”

However, as with Stanford, Yale’s program is less explicit in its use of participatory design and social cartography. While stakeholder engagement is emphasized, the program does not foreground the co-creation of knowledge and solutions to the same extent as Parques Nacionales: Pasado, Presente y Futuro. Our course’s emphasis on elevating human stakeholders’ sketches and oral histories alongside quantitative data represents a significant innovation in participatory, equity-centered pedagogy.

#### **4.3 ETH Zurich: Design Thinking for Sustainable Development**

ETH Zurich’s Design Thinking for Sustainable Development course introduces participants to the design thinking process, methods, tools, and mindsets, with a focus on sustainable development challenges [32]. The course is human-centered, iterative, and encourages participants to step out of their typical modes of thinking. Case studies and practical applications are used to illustrate the effectiveness of design thinking in addressing sustainable development goals.

ETH’s approach is notable for its emphasis on creativity, innovation, and the iterative nature of design thinking. Participants learn to apply design thinking tools to real-world challenges and to reflect on their experiences. However, the course is typically shorter in duration and less embedded in local contexts than Parques Nacionales: Pasado, Presente y Futuro. Our course’s integration of social cartography, participatory workshops, and community-driven innovation represents a deeper engagement with local realities and the co-creation of solutions.

### **5. Synthesis: Toward a Pluriversal Conservation Pedagogy**

While the course shares DNA with programs like Stanford’s ANTHRO 25SC, which immerses students in Patagonian conservation conflicts, its integration of social cartography and participatory design marks a departure from Eurocentric models. Yale’s Tropical Forest Landscapes Certificate focuses on policy and ecology, excelling in training technical experts but lacking mechanisms for community co-design. The Parques Nacionales course, conversely, treats policy as an emergent property of grassroots innovation [18].

ETH Zurich’s Design Thinking Lab, though rigorous in prototyping, often privileges techno-solutions over cultural context. In Cercados entre Cerros, AR tools were secondary to the relational labor of community sessions. Cambridge’s MPhil in Conservation Leadership, while groundbreaking in ethical training, can marginalize hyperlocal knowledge. Our course roots solutions in place-specific histories, such as Guasca’s post-conflict land tenure disputes [2].

The comparative analysis reveals that while Stanford, Yale, and ETH Zurich offer valuable models of interdisciplinary and experiential learning, Parques Nacionales: Pasado, Presente y Futuro

distinguishes itself through its commitment to participatory design, social cartography, and the elevation of diverse knowledge systems. By centering campesino sketches alongside satellite data, AR alongside oral histories, the course models a conservation ethos that is relational, iterative, and anticolonial. As biodiversity (and climate) crises intensify, this approach offers a blueprint for training conservationists capable of navigating complexity without sacrificing equity.

## 6. Challenges: Cartographies of Power and Resistance

Despite its successes, the course confronts systemic barriers mirroring those in earlier work on informal settlements. Policymakers often dismiss hand-drawn community maps as “anecdotal,” privileging remote-sensing data. Students countered this by printing farmers’ sketches into tangible models for congressional hearings [19]. Funding models tied to short-term metrics, such as visitor numbers, neglect long-term relational outcomes like trust-building. E.g., the Laguna de Guatavita team addressed this by linking funding to campesino-led monitoring councils [30].

Disciplinary hierarchies also emerged, with biological science students initially resisting design students’ “messy” iterative methods, echoing tensions observed between designers and sociologists. At the same time, design students found themselves challenged by the rigor and specificity of scientific knowledge brought by their peers in the biological sciences, sometimes struggling to integrate empirical data and methodological precision into their creative processes. Both groups faced difficulties in communication and the integration of distinct disciplinary languages and priorities, a phenomenon widely recognized in the literature on design-based interdisciplinary learning (Zimmerman, 2023). Furthermore, many students took time to become comfortable with the course’s learning-by-doing approach, which stands in contrast to the traditional, lecture-based model where teachers provide structured content that students are expected to follow closely. Initially, some students expressed discomfort with the ambiguity and open-endedness of project-based, experiential learning, preferring the familiarity of clear instructions and predetermined outcomes. Over time, however, regular feedback sessions helped reframe maps and prototypes as boundary objects for dialogue and knowledge integration, facilitating mutual understanding and collaboration across disciplines [27][28]. This gradual adaptation to active, project-based learning mirrors findings in higher education research, which notes initial resistance but ultimately highlights the enhanced engagement, critical thinking, and collaborative skills fostered by such pedagogical models [12].

## 7. Student Reflections and Transformative Learning

Students reported that the interdisciplinary, participatory approach transformed their understanding of conservation. One biology student reflected, “Working with campesinos taught me that ecological data alone cannot resolve conflicts. Their hand-drawn maps revealed how ancestral crop rotation systems prevent soil erosion—a solution no satellite image could capture.” A design student noted, “We realized ‘conservation’ meant something different to each stakeholder. Den Ouden’s framework [11] forced us to quantify trade-offs—like how a 15% yield loss for farmers could prevent 30% biodiversity decline.” These reflections underscore the importance of relationality, iterativity, and decolonization in conservation education [26].

## 8. Discussion: Pluriversal Conservation Pedagogy

Parques Nacionales: Pasado, Presente y Futuro embodies a novel reimagining of conservation through pluriversal cartography—a practice that transcends mere spatial mapping to weave together diverse epistemologies, values, and lived experiences [13][21]. By elevating human stakeholders’ hand-drawn sketches to the same legitimacy as satellite imagery and oral histories of Indigenous elders to the sophistication of AR tools, the course dismantles the colonial binaries that have long fractured conservation praxis.

This ethos is rooted in three transformative principles: (1) relationality, where trust-building with communities supersedes transactional project deliverables; (2) iterativity, which embraces uncertainty through cyclical prototyping rather than rigid solutions; and (3) decolonization, actively eroding hierarchies between institutional “expertise” and ancestral wisdom.

As biodiversity loss accelerates, this model does not merely train conservationists—it cultivates bridge-builders who navigate complexity without compromising equity. The urgency of this vision extends far beyond academia: it is a lifeline for ecosystems buckling under extractive ideologies, and for communities whose survival hinges on reclaiming their rightful place as stewards, not subjects, of conservation. Here, conservation projects become living dialogues—not tools of domination—and education transforms into an act of solidarity with both land and people.

## 9. Conclusion

The interdisciplinary framework presented by Parques Nacionales: Pasado, Presente y Futuro offers a replicable model for transformative conservation education. By integrating participatory design, systems thinking, and social cartography, the course equips students to address the complex socio-ecological dilemmas facing Colombia's protected areas. The curriculum's emphasis on community engagement, iterative prototyping, and multimodal storytelling fosters trust, adaptability, and decolonization praxis. Comparative analysis with global programs highlights the unique contribution of this model to participatory, equity-centered pedagogy. As environmental challenges intensify, such pluriversal cartography provides a vital blueprint for training conservationists capable of navigating complexity without sacrificing social justice.

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