ECOLOGY, SOCIETY, AND SELF: TOWARD A MULTI-TIERED FRAMEWORK FOR PARTICIPATORY APPROACHES IN KNOWLEDGE GENERATION

by

ASHLEY MARIE STUDHOLME

A THESIS

Presented to the Environmental Studies Program
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Master of Science

June 2018

THESIS APPROVAL PAGE

Student: Ashley Marie Studholme

Title: Ecology, Society, and Self: Toward a Multi-Tiered Framework for Participatory Approaches in Knowledge Generation

This thesis has been accepted and approved in partial fulfillment of the requirements for the Master of Science degree in the Environmental Studies Program by:

Kathryn Lynch	Chairperson
Raoul Liévanos	Member

and

Sara D. Hodges	Interim Vice Provost and Dean of the Graduate School

Original approval signatures are on file with the University of Oregon Graduate School.

Degree awarded June 2018.

THESIS ABSTRACT

Ashley Marie Studholme

Master of Science

Environmental Studies Program

June 2018

Title: Ecology, Society, and Self: Toward a Multi-Tiered Framework for Participatory Approaches in Knowledge Generation

Participatory approaches in knowledge generation have become increasingly important in understanding our environments and integrating human and natural systems. Such approaches have been used to discover new species, address environmental injustices, and develop land management practices. However, frameworks and models used to explore participatory approaches tend to be oversimplified or focus on a specific component. Here, I present an integrated multi-tiered framework to gain insight into how project context and design interact to create outcomes that shape the socio-ecological system. The framework accounts for the nested scales, i.e. ecological, societal, and individual, of both the context and the outcomes. I then demonstrate the utility of the framework by applying it to two case studies in Ecuador: 1.) a climate change monitoring network and 2.) Andean bear para-biologists. Using this framework, it was evident that in both projects, gendered landscapes and how participants engaged were primary factors in shaping outcomes.

CURRICULUM VITAE

NAME OF AUTHOR: Ashley Marie Studholme

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon, Eugene
University of Virginia, Charlottesville

DEGREES AWARDED:

Master of Science, Environmental Studies, 2018, University of Oregon
Bachelor of Arts, Biology, 2007, University of Virginia
Associate of Science, General Studies, 2005, Northern Virginia Community College

AREAS OF SPECIAL INTEREST:

Urban Ecology
Public Engagement

PROFESSIONAL EXPERIENCE:

Food Studies Program Assistant, University of Oregon, September 2017 – June 2018

Graduated Employee Teaching Apprenticeship, University of Oregon, September 2016 – June 2017

Associate Scientist, Universidad de Cuenca, January 2014 – July 2016

Project Coordinator and Lead Biologist, Universidad Nacional de Chimborazo, June 2012 – December 2013

Natural Resources Volunteer, Peace Corps Ecuador, February 2009 – June 2012

Water Resources Technician, Albemarle County - Water Resource Department, September 2007 – December 2008

PUBLICATIONS:

Studholme, A., D. Finn, H. Hampel, R.F. Vázquez. 2017 Secondary Production of Caddisflies Reflects Environmental Heterogeneity Among Tropical Andean Stream. Hydrobiologia. 797(1) 231- 246

Pinos, J., A. Studholme, A. Carabajo, C. Gracia. 2017. Litterfall and Decomposition of Polylepis reticulata in the Treeline of Ecuadorian Andes. Mountain Research and Development. 37(1) 87-96

Studholme, A., L. Hipo, A. Ríos, C. Recalde. 2014. Altitudinal and Temporal Variability of Four Macroinvertebrate Communities in Andean Streams, Sangay National Park, Ecuador. Entomotropica. 29(3) 149-158

Studholme, A. 2012. Manual Metodológico para el Monitoreo de Calidad de Agua con Macroinvertebrados. CESA-AVSF. Riobamba, Ecuador

ACKNOWLEDGMENTS

I wish to express sincere appreciation to Professors Lynch and Lièvanos for their assistance in the preparation of this manuscript. In addition, special thanks are due to Corperación Grupo Randi Randi for allowing me to join their community visits, both CGRR and Fundación Cordillera Tropical for taking the time to speak with me, and community participants in El Ángel for welcoming me and sharing their stories. This study was conducted with IRB approval via protocol RCS 06272017.030.

I dedicate this to my dad for instilling in me a love of nature from a very young age and to my mom for showing me that empathy for others is key for community healing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

Currently, the Global Footprint Network estimates that we use 1.7 earths to sustain our collective lifestyles (GFP 2018). This overshoot likely began in the 1970s as the rate of converting natural resources (e.g. fossil fuels, forest products, and minerals) into consumable products for profit outpaced the rate that natural processes can regenerate (Toth and Szigeti 2016). These global trends manifest locally as social and ecological inequities that test the socio-ecological resilience of our earth system (Berkes, Folke, and Colding 1998). The environmental impacts of the commodification of nature and the subsequent generated pollution disproportionately affect poor communities and communities of color, thus exacerbating environmental injustices (Bullard 1994; Johnston 1994) and resulting in high extinction rates of flora and fauna (Ceballos et al. 2015), which have likely contributed to climate change (Steffen et al. 2015). These manifestations culminate into the what I refer to as the ecological divide or the human-nature gap (Scharmer 2009), where the interactions between humans and their environments result in an inequitable and unstable socio-ecological system.

To address this ecological divide, we must first see how it manifests at local scales through generating knowledge of socio-ecological systems. Socio-ecological systems (SES) are those where human interactions and relationships are "mediated through interactions with the biophysical and non-human biological units" (Anderies, Janssen, and Ostrom 2004). These systems are complex and dynamic, i.e., distinct components interact conjointly and create feedbacks and cycles nested within various time and spatial scales (Holling 1998). Such components include resource systems and units, governance systems, actors, and action situations (Ostrom and Cox 2010). Given the complexity of these systems, the governance and management strategies of SES are equally complex and require multi-scale and place-based approaches (Ostrom and Cox 2010). Addressing the human-nature gap then requires generating knowledge on multiple spatial scales, from local to global.

Historically, academic knowledge generation of our environment has excluded multiple views and marginalized other epistemologies. Upper-class, white men have been the curators of scientific knowledge recognized in western academic cultures. Other voices and perspectives, including those of women and people of color, have either been largely absent or invisible (Fehr 2011). Other knowledge systems such as feminist epistemologies (Grasswick 2011), traditional ecological knowledge (Berkes, Colding, and Folke 2000), place-based knowledge (Haywood, Parrish, and Dolliver 2016) and native science (Black Elk 2016) has been disregarded, leading to distrust of scientific expertise (Collins and Evans 2007; Corburn 2005) and limitations in how science addresses relevant concerns of the general public, particularly when both risks and uncertainties in knowledge are high (Funtowicz and Ravetz 1993). Through inclusive democratic processes, "science revalues forms of knowledge that professional science has excluded and democratizes the inquiry and decision-making processes" (Corburn 2005, p.3).

Knowledge generation processes aimed at understanding the ecological divide necessitate participatory and interdisciplinary approaches (see O'Brien, Marzano, and White 2013) to both analyze the different socio-ecological components and how they interact, and apply that knowledge to formulate solutions that support both the people and their environments. All local actors (i.e., participatory) and disciplines (i.e., interdisciplinary) have valuable expertise, but they also have limitations regarding what they can perceive and what they know. Knowledge held by any one person is always situated (Haraway 1988) and partial (Murray 1983), but through a collaborative process, a group may be able to collectively understand SES complexity wherein multiple actors share their knowledge and/or generate new knowledge about the SES (Daniels and Walker 2001b). Such an approach where experts across disciplines collaborate with local experts, which live within the study environment, is both participatory, i.e., engaging with local actors through a democratic process, and interdisciplinary, i.e., requiring both natural and social sciences (O'Brien, Marzano, and White 2013).

Participatory interdisciplinarity varies in nomenclature, type of knowledge generated, and what results occur. For example, participatory approaches have been referred to in the literature as citizen science (Irwin 1995), street science (Corburn 2005), participatory action research (Reason and Bradbury 2008), participatory modeling (Gray et al. 2018), public experiential science (Healy 2009), people-powered science (Moore 2006), public participation in scientific research (Shirk et al. 2012) and cooperative research joint learning (Cullen-Unsworth et al. 2012). These approaches have been used globally to gain understanding in a wide range of circumstances, including forest ecology in the Olympic Peninsula in Washington (Ballard and Belsky 2010), water resources in Nepal (Buytaert et al. 2014), and freshwater turtles in Ecuador (Townsend et al. 2005), which have resulted in enhanced environmental learning, improved ecosystem service management, and sanctioned management rights for local tribes, respectively, thus highlighting the variety of outcomes found among participatory approaches.

While public participatory approaches have been a part of scientific discovery for centuries (Miller-Rushing, Primack, and Bonney 2012), they have been largely hidden and only in the last decade have gained recognition in the scientific literature. One of the longest-running and most iconic citizen science projects is Audubon's Christmas Bird Count, which began in

1900 when ornithologist Frank Chapman and twenty-seven bird enthusiasts proposed counting birds during the holiday rather than hunting them in the traditional Christmas 'side hunts.' Today, tens of thousands of volunteers from across the globe survey bird diversity and contribute to the Audubon's bird census database (Butcher 1990). Still, citizen science as a recognized method has been used relatively sparsely in the academic literature until recently. An estimated 50% of articles published prior to 2011 that enhanced our understanding of migratory birds and climate used a citizen science method, however none named this method as such and many papers relegated credit to volunteers to the acknowledgements section (Cooper, Shirk, and Zuckerberg 2014). Follett and Strezov (2015) found that the number of published articles focusing on citizen science in astronomy, environmental studies, biology, medical and other fields remained under 50 per year until 2010, and has since increased dramatically to over 150 per year in 2014, demonstrating the scientific community's increased recognition of public participatory approaches.

The proliferation of these projects has influenced the academic community to analyze social and ecological aspects of participatory approaches. By developing a framework to increase environmental steward effectiveness (Conrad and Daoust 2008), addressing ethical issues (Resnik, Elliott, and Miller 2015), demonstrating faster knowledge to action translation (Danielsen et al. 2010), and integrating human and natural systems (Crain, Cooper, and Dickinson 2014), studies have explored many key elements of participatory approaches. While many studies exist, frameworks have been either specific to one component or overly simplistic to effectively examine these approaches in a holistic way. An integrated multi-tiered framework is needed to gain insight into how project context and design interact to create outcomes that shape the socio-ecological system.

Here, I first present my multi-tiered framework to explore the outcomes of participatory approaches that generate knowledge on the ecological divide. First, I developed a multi-tiered framework based on both personal experience as a citizen scientist and a literature review. This allowed me to simultaneously identify higher and lower tiers through a coupled deductive-inductive approach, where deductive means from the literature and inductive means from my personal experience. Then, I analyzed the efficacy of my framework by applying it to two case studies in Ecuador: 1.) Climate change monitoring network and 2.) Andean bear para-biologists. Based on these findings, I identify further areas of research moving forward.

CHAPTER II

POSITIONALITY

Knowledge and how I understand the world is shaped by my identity, culture, and life experiences (England 1994); therefore, objectivity, or what Sandra Harding calls "strong objectivity," in conducting research is linked to being aware of my position in the world and how it shapes my worldview (Harding 1995). Here, I reflect on my positionality in relation to the construction of my framework and test it in the field as an outsider (Merriam et al. 2001), thus acknowledging potential biases that may influence the present research (Rose 1997).

Both my past experiences as a citizen scientist and my subsequent training as an ecologist, influence my entry point in this research. My experiences as a citizen scientist have led me to have a positive view of participatory approaches. I have participated in monitoring hawks, collecting data on bike routes, and analyzing camera trap photos on the crowdsourced citizen science website zooniverse (https://www.zooniverse.org/). Each experience was different, but here I will only highlight hawk monitoring, as it impacted me the most. From the age of 11, I would join my dad in volunteering at the Cape May Raptor Banding Project every fall in Cape May, New Jersey. One week out of each year, my dad and I - along with other family members - would monitor the hawk migration from sunrise until sunset. We ate together, told stories and shared unique experiences interacting with birds-of-prey. These were times that inspired me to study biology and ecology in college, but more so I cherish these as moments spent with my family, where we strengthened our relationships with each other through studying nature. I was motivated by the relationships I formed, the knowledge I gained, and the feeling that my contributions mattered.

Being a citizen scientist inspired me to study biology and ecology in college as an undergraduate. Therefore, my viewpoint into this interdisciplinary study is largely that of an ecologist. My training as an ecologist prepared me to understand the methods implemented in participatory approaches focused on ecological studies and to note the interactions and feedbacks among the components of each case study. However, I felt less fluent regarding the sociological, political, economic, anthropological, etc., viewpoints of this study. As a result, the proposed framework may benefit from additional development rooted in other disciplinary perspectives.

My positionality in relation to my identity as an outsider and my past experiences in Ecuador shaped how I conducted fieldwork for this study. I arrived in Ecuador in 2008 as a Natural Resources Peace Corps Volunteer, where I lived with two different host families: one family during Peace Corps training and another family at my eventual site in Riobamba. During that time, I collaborated with a local Ecuadorian NGO (Non-Governmental Organization), Centro Ecuadotoriano Servicios Agricolas (CESA), on an integrated watershed management project, which included collecting water quality and quantity data, environmental education, and stakeholder analysis to identify local water issues and needs. After completing my Peace Corps experience, a local university hired me to study aquatic ecology in a section of Sangay National Park. For the next four years, I worked as an ecologist studying tropical Andean Ecosystems. Through these lived experiences I gained a level of tacit knowledge about Ecuadorian culture both professional and informal, but this knowledge is filtered through my position as a white, female, outsider from the US. My cultural and familial upbringing, my race, my gender all influenced how I interacted with Ecuadorians both professionally and personally and how people, whether from my counterpart organization or from the rural areas, perceived me.

When visiting rural areas, local people would often inform me that they needed help because they were poor or uneducated and occasionally I was directly asked for money or other means of support. These encounters seem to have stemmed from how international development work had occurred in the past and shaped a narrative that said if you show a white person that you are helpless and poor they will act as a "rescuer" and donate materials and supplies to your community (Toomey 2011). I felt uncomfortable and uncertain as to whether my presence was more disempowering than helpful. I joined the Peace Corps to learn from others in a cross-cultural context and support their vision for a better life, but I entered a complicated historical context that challenged my intention. I felt unsure how to be generous and supportive in a way that empowered others.

My training as an ecologist did not prepare me to explore these questions, so I focused on what I was trained to do, i.e., ecological research. I developed water quality monitoring protocols using bioindicators within the local watershed, studied secondary production in Andean lotic systems and analyzed carbon cycles in endemic high-altitude woodlots. I collaborated with various Ecuadorian NGOs and universities to generate ecological knowledge of understudied Andean ecosystems and I felt it was important to contribute to this body of literature. I later realized that how I generated and transferred knowledge perpetuated a form of knowledge mining. I extracted knowledge about a place and published it in English speaking journals inaccessible to my co-workers that collaborated with me or to local communities that granted us access to the study sites. To address this form of knowledge mining, I became interested in exploring approaches that strengthened collective knowledge beyond the scientific community.

CHAPTER III

FRAMEWORK DEVELOPMENT

I constructed a preliminary multi-tiered framework to build theory surrounding the increasingly recognized field of participatory approaches in knowledge generation. In systems thinking, analyzing situations and theory building constitute an iterative complimentary process that begins with creating a highly-detailed situation map (Checkland 1999), thus leading to developing conceptual models and frameworks needed for constructing an applied theory (Daniels and Walker 2001a). Developing frameworks is an important part of theory building, as they provide "general classes of variables that are necessary to explain phenomena" (Schlager 2007). By analyzing case studies, scholars identify case-specific variables, and through a process of aggregation, move from specific knowledge to a more general understanding. Likewise, I developed my framework through an iterative process, drawing on personal experience and previous studies, and applied this framework to two case studies.

My framework is embedded in the Iceberg Model (Figure 1), which is adapted from the Theory U, and links environmental issues to deeper paradigms of thought (Scharmer 2009). The Theory U applies to the analysis of any divide, but here, I adapted it to show how the *design* of the participatory projects aimed at exploring the ecological *context* yields *outcomes* on the individual, social, and ecological levels. The Iceberg Model classifies issues we see into three categories: ecological divides, social divides, and individual divides. Ecological divides, mentioned previously, are the gaps experienced between humans and nature; social divides are the gaps experienced between humans and other humans; individual divides are the gaps experienced between the self and the potential self or actualized self. These gaps manifest into what we see, i.e., the "tip of the iceberg," which are rooted in structures and systems, created by paradigms of thought, and formed from some underling source.

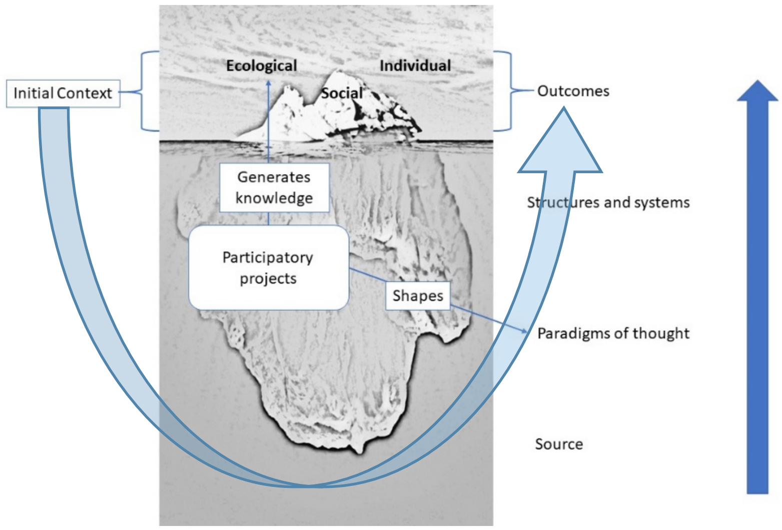

Figure 1: Iceberg model adapted from (Scharmer 2009) connecting ecological, social, and individual outcomes to paradigms of thought. Ecological issues result from gaps between humans and nature; social issues result from gaps between humans and other humans; and individual issues result from gaps between the self and the potential or actualized self. Boxes indicate modifications to the original model to reflect the initial stages of developing the multi-tiered framework (**Error! Not a valid result for table.**).

My framework explores how to generate knowledge on the ecological gap through participatory approaches, yielding outcomes at the individual, social and ecological levels. The context and project design interact and can shift paradigms of thought, leading to shifts in structures and systems through a process known as the Theory U, where the context and participatory design approaches shape outcomes through a process of relationship building between the self and self, self and others, and self and nature. In developing my framework, first I generated questions for each parameter, then I integrated existing models and typologies from the literature to construct a multi-tiered framework. Each tier goes from the general to the specific, and allows researchers and practitioners to adapt the framework to specific cases while also enabling comparison across cases.

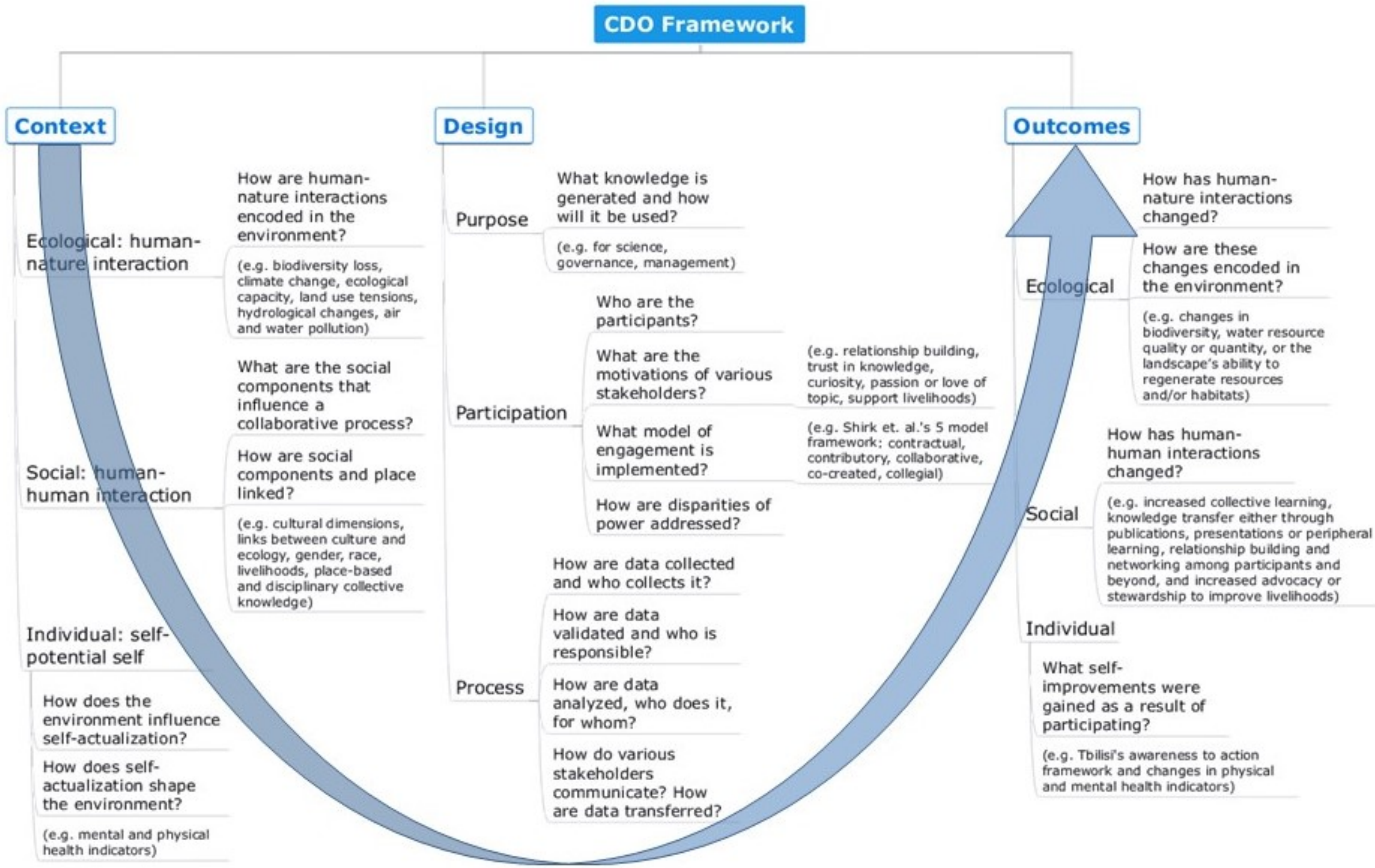

Figure 2: Multi-tiered CDO framework linking context, project design, and outcomes (CDO).

Context

Context is used to explore ecological, social, and individual components of an ecological divide. The lower tiers are not exhaustive, but provide examples that may be important for exploration in the given ecological, social, and individual contexts. Ecological contexts of the divide are how human-nature interactions are encoded in the landscape, which may manifest as biodiversity loss (Ceballos et al. 2015), climate change (IPCC 2001), ecological capacity (or the ability of the ecosystem to regenerate and provide resources to local inhabitants; Rees 2006) land-use tensions (Himley 2009), hydrological changes (Buytaert et al. 2014), or air and water pollution (Arellano et al. 2017). Given the participatory approach, it is important to identify and understand the social components that influence a collaborative process (Daniels and Walker 2001b) and how social dimensions (such as culture, class, race and gender) and place are linked (Escobar 2006). Social context includes cultural dimensions of time (Hall 1989) and cross-cultural communication (Hofstede 1991), as well as how cultures and ecologies have co-evolved (Safarzynska 2013), how gender roles create gendered landscapes (Paulson 2016), the well established link between race and land in terms of appropriation and access (Pulido 2015), the relationship between livelihoods and natural resources particularily for rural poor communities (Fisher et al. 2014) and the collective place-based or disiplinary expertise (Collins and Evans 2007) relavent to the ecological divide, where joint fact-finding processes facilitate collaborative action (Matsuura and Schenk 2017; Brown and Lambert 2013). Gender, in particular, is considered a universal organizing principle in social relations (Glick and Fiske 1999) and shapes who uses natural resources and how they use them (Moser 1993), as well as the knowledge and governance/management of nature (Harcourt 1994; Rocheleau, Thomas-Slayter, and Wangari 1996). Individual components of this divide include ways in which the environment influences how the potential self is realized or how self-actualization consists of psychological or individual factors that influence how individuals interact with others or with their environment. Interacting with nature has been shown to improve various mental and physical health indicators such as stress recovery (Ulrich et al. 1991; Lee et al. 2015), depression and exercise (Pretty et al. 2007). While I have included the individual gap within the framework, it is an area that goes beyond the scope of this project and my current expertise. Moving forward, the framework would benefit from developing this component further.

Design

Context informs many aspects of project design, including, purpose, participation, and process. Participatory approaches generate knowledge for several purposes including: 1) developing a better understanding of the world through science, 2) addressing injustices through better governance and policy, and 3) strengthening resilience through management practices (Silva 2016). Examples of scientific findings from citizen scientists abound, ranging from the discovery of six new litter-dwelling beetles in Borneo (Schilthuizen et al. 2017), the discovery of a new frog species in the Colombian Andes (Amézquita et al. 2013) to the over 200 publications analyzing Audubon's Christmas Bird Count data ("Christmas Bird Count Bibliography" 2015). Lois Gibbs collected data and organized her community to address the injustice of her neighborhood being built on a toxic waste site. As a result of the community's efforts to generate knowledge, challenge expert opinion and mobilize, they effectively lobbied the government to have the Love Canal declared a Superfund site, and both the New York state and the federal government covered relocation costs and initiated clean up (Konrad 2011). To strengthen resilience, urban residents in Brooklyn, New York, apply agricultural knowledge to create urban gardens and contribute to urban foodways or improve stormwater management

(Krasny and Tidball 2012). Each purpose is related to potential ways that the knowledge generated might be used to produce various outcomes, as well as how it may influence the characteristics of participation and the project process.

The characteristics of participation include who participates, participant motivation for engaging in projects and various levels of engagement or engagement models. Who participates should reflect the social context to ensure that participatory approaches adequately represent varying viewpoints and knowledge. Participatory approaches often intersect with volunteerism (Cohn 2008) and political engagement (Spiegel et al. 2011), shaping participant motivations and levels of engagement, which in turn may support various project outcomes. Motivations to engage in participatory projects may include: relationship building, as was my motivation to participate in the Cape May Raptor Banding project with my dad; trusting the knowledge generated, as is the case in many environmental conflict resolution projects (Matsuura and Schenk 2017); curiosity in or passion and love of the topic, as in the Christmas Bird Count (Butcher 1990); or supporting livelihoods, as in the Cofán tribe in Ecuador, who conducted turtle surveys to lobby the government and gain control of managing their lands (Townsend et al. 2005). While this list is far from exhaustive and motivations tend to be dynamic, I assert that these four capture the majority of motivations.

Stemming from these motivations are various levels of engagement or ways in which participation occurs. Whether it is scientists recruiting volunteers to collect bird data (Butcher 1990) or community members turning to scientists to help them analyze the water crisis in Flint, Michigan (Hohn 2016), levels of engagement vary from top-down models to grassroots models of participation. While many models exist, including Arnstein's (1969) “Ladder of Participation,” Bonney et al.'s (2009) three Cs – contributory, collaborative and co-created – and

Wiggins and Crowston's (2011) five typologies of citizen science; I selected Shirk et al.'s (2012) five-model framework, which consists of the five components described below:

- Contractual projects, where communities ask professional researchers to conduct a specific scientific investigation and report on the results;
- Contributory projects, which are designed by scientists while the public assist with data collection;
- Collaborative projects, which are initially designed by scientists, and public participants in addition to collecting data also help refine the project design, analyze data, and disseminate findings;
- Co-created projects, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process;
- Collegial contributions, where non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals.

Embedded within both motivations and engagement levels are underlying power dynamics (O'Brien, Marzano, and White 2013). While this is a concept that can and should be further developed in this framework, it is not within the scope of this research; thus, I will only mention it here to emphasize its importance in all social interactions, and note that power differentials must be addressed for collaborative processes to be effective (Clarke and Peterson 2016).

Purpose and participation both influence the process of the project. The process includes components that move the project along from data collection, to data validation and analysis, and finally to communication pathways for participants. Data collection includes what data are collected, what methods are used and who collects it. Data validation involves how and who reviews the data for quality assurance (Wiggins et al. 2011), while data analysis explores how and who analyzes the data and for whom, i.e., who will use the data. Communication pathways explore ways in which participants communicate throughout the process.

Outcomes

The project context and design interact to create ecological, social, and individual outcomes, and mirror the initial attributes of the initial context. In accordance with the theory U, environmental outcomes resulting from shifts in human-nature interactions begin with individual transformations, which build into collective action that shape human-to-human and human-to-nature interactions. Ecological outcomes may include changes in biodiversity, water resource quality or quantity, or the landscape's ability to regenerate resources and/or habitats. Social outcomes include increases in collective learning and the transfer of knowledge to other generations (Brown and Lambert 2013), increased knowledge transfer either through publications or peripheral learning where participants share their knowledge gain with friends and family (Stone et al. 2014), relationship building and networking among participants and beyond, and increased advocacy or stewardship to improve livelihoods. Danielsen et al. (2010), for example, concluded that translating knowledge into action can be significantly faster (1 - 3 yrs.) when the citizen science approach is used, particularly at local scales, compared to monitoring projects conducted by scientists only (5 - 30 yrs.). Individual outcomes include personal development through gaining awareness, knowledge and skills leading to changes in attitudes and actions (see awareness to action framework in the 1977 Tbilisi declaration) or changes in physical and mental health indicators, including reducing stress and symptoms of depression (Song, Ikei, and Miyazaki 2016). The latter is outside the scope of this study but is included to here to demonstrate the nested scales, including both the context and the outcomes. Future research may explore the connection between mental and physical health to the broader social and ecological issues we face.

CHAPTER IV

METHODS: TESTING THE FRAMEWORK

Ecuador's Ecological Context

Ecuador, situated on the Pacific coast of South America, is a megadiverse and plurinational (Becker 2012) country. Megadiverse nations include a list of 17 countries that account for about 10% of land area but are home to 60%-80% of the earth's biodiversity (Mittermeier and Mittermeier 1997). Ecuador's status as a megadiverse nation is a result of both its geographical location near the equator, where biodiversity peaks globally (Gaston 2000), and its complex topography, which promotes endemism (Nogué, Rull, and Vegas-Vilarrúbia 2013). The Andes mountains run north to south through the country, dividing it into three regions: the coast, the Sierra, and the Amazon rainforest. Both the coast and the Sierra also contribute to segments of two conservation hotspots: Tumbes-Chocó-Magdalena and Tropical Andes (Mittermeier 2004). Hotspots are areas noted for their high diversity and endemism but which are currently under threat due to high rates of land-use change and climate change. Tumbes-Chocó-Magdalena hugs the coastal region enclosed by the Pacific Ocean to the west and the western slopes of the Andes to the east, and also includes the renowned Galapagos Islands (Rodríguez-Mahecha et al. 2004). The Tropical Andes Hotspot, which extends well beyond Ecuador's borders, traverses north to south along the spine of the country and is considered to be the most diverse hotspot on the planet (Rodríguez-Mahecha et al. 2004). In addition to the two hotspots, the eastern slopes of the Andes transition into the Amazon rainforest, one of the most important terrestrial ecosystem that modulates the global carbon budget (de Almeida Castanho et al. 2016).

Both case studies are located in the Andes, where the páramo is the dominant vegetation type and which has been shaped through human interaction for thousands of years. The páramo ecosystem commences in Colombia (near 11 N) and extends south through Peru (8 S), covering approximately 35000 km^2. It ranges from the closed tree line at about 3000 m to the snow line at around 4800 m (Cuesta and Becerra 2009); note however that there has been debate regarding the lower limit due to human activity (Luteyn 1992). The páramo is divided along the altitudinal gradient into three belts: the super páramo (4100 – 4800m a.s.l.), the grass páramo (3500-4100m a.s.l.) and the subpáramo (3000 – 3500m a.s.l.). The super páramo is characterized by sparsely vegetated plant communities adapted to high solar radiation, low temperatures, and low water availability. The grass páramo is dominated by tussock grasses and is described as a tropical grassland. The subpáramo is the most biologically diverse belt, as the region is comprised of a mosaic of grasses, shrubs, and low-growing trees (Luteyn 1992). Some studies suggest that páramos have extended their lower limit as a result of human activity, defragmenting the tree line by fire and cultivation and thus providing opportunities for páramo plants to establish themselves post-disturbance (Laegaard 1992).

Ecologically, the páramo is recognized for its high endemism and unique hydrology, which in turn has made it socially significant in providing food and critical water resources. Many crops that are used globally such as potatoes and Quinoa originated in the Andes mountains, in addition to numerous other crops of local significance such as pearl lupine (or chocho), banana passionfruit (or taxo) and tamarillo or tomate de árbol in Spanish (Hernández Bermejo and León 1994). Hydrologically, the páramo comprises the headwaters and baseflow for streams and is a critical water resource for cities such as Quito, Bogota, and Lima (Célleri and Feyen 2009; Buytaert and De Bièvre 2012) as well as more arid regions along the western slopes (Viviroli et al. 2007).

Ecuador's Social Context

Ecuador is also home to an ethnically and culturally diverse population of 15 million (INEC 2010). Both the history of native peoples and of colonialism (Gareis 2005) has shaped the present day ethnic and cultural landscape (Castillo and Cairo Carou 2002). Indigenous tribes (~7% pop.) have inhabited the territory now known as Ecuador for more than 10,000 yrs (Fraser 2014). They currently live in scattered pockets throughout the coast (less than 1% of the indigenous pop.) and Amazon region (4-6%), while the majority (~90%) live throughout the páramo (Gerlach 2003). These tribes speak about 20 indigenous languages, including nine regional dialects of Kichwa (Simons and Fennig 2017). Mestizos account for the largest portion of the population at over 78%, but regional ethnic identities can be distinct. For example, the mestizo people of the coastal countryside or the Montubios (~7% of the population) protested to be recognized as a separate ethnic group, which in 2001, the government officially granted (Roitman 2008). Afro-Ecuadorians (7% pop.) mostly live in the North and Northwest provinces, where escaped African slaves managed to establish settlements in the 1600s and lived alongside indigenous tribes that populate the region (Torre and Striffler 2008).

While the legacy of colonialism influenced the ethnic diversity in relatively obvious ways (namely Spanish language and Catholicism), Spanish settlers, through imposing their colonial identity on native peoples, have shaped the present day cultural landscape in ways that are challenging to parse (Castillo and Cairo Carou 2002). Previous studies have explored various cultural dimensions of Ecuador, namely: monochronic / polychronic time (Hall 1989), high / low power distance, and collectivist / individualist culture (Hofstede 1991). Ecuadorians tend to view time as flexible and engage in several different activities as once indicative of the polychronic view of time. This view stands in stark contrast to monochronic societies in the U.S. and many Western European countries that tend to adhere to strict schedules and follow a sequence of events (Hall 1989; Petkova 2015). In terms of Hofstede's cultural dimensions, Ecuador ranked as having high power distance with a collectivist nature (Hofstede 2018). High power distance means that society generally accepts a hierarchal structure and uneven power distribution while a collectivist culture means that Ecuadorian identity tends to be defined as part of their in-group before individual characteristics. In collectivist societies, harmony within the group and maintaining relationships tend to be valued more than speaking your mind (Hofstede 2011). Each cultural dimension may vary from community to community and person to person, reflecting the challenges in recognizing the importance of culture while not perpetuating stereotypes.

In addition to ethnic diversity and cultural dimensions, previous studies have noted gendered landscapes in Latin America (Paulson 2016) and in the Andes specifically (Paulson 2003; Radcliffe 2014). Paulson (2003) noted that while there is gendered division of labor, it is more nuanced than simply a list of men's vs. women's tasks and is linked to geography and agricultural cycles. Men for example tend to be responsible for primary crops such as potatoes and corn planted in larger fields, while women tend to be responsible for the secondary crops such as fava beans and squash planted in smaller plots or intercropped with corn. In addition to gendered division of labor, official interpretations devalued women's labor contributions and as a result during agrarian reform in the 1964 and 1973, women were not granted land rights. Women-led households still have less access to land than men-led households (Radcliffe 2014).

Ecuador has a complicated relationship between nature and citizen well-being. The 2008 constitution of Ecuador was the first the grant rights to nature and natural processes (Title II, Ch. 7, article 71) and links nature rights to the idea of *sumac kawsay*, an indigenous concept roughly translated as living well in the community, including nature (Lewis 2016, p. 177). Meanwhile, Ecuador's economy relies on natural resource extraction, such as petroleum (oil and natural gas) and mineral ores (namely gold, but also copper and silver), and agricultural products, such as bananas, coffee, and shrimp (CIA 2017). Each of these land-uses reduces and pollutes habitats for flora and fauna (Laurance, Sayer, and Cassman 2014; Arellano et al. 2017), changes the hydrology of the area (Buytaert et al. 2006), and disproportionately impacts rural poor populations, particularly in the Amazon, by contaminating water supplies and thus leading to higher cancer rates (Hurtig 2002). However, taxes from these activities fund state programs, which for the last decade under then president Rafael Correa included many programs that have aimed at helping disenfranchised communities and improving infrastructure (Riofrancos 2015). Since Correa was elected in 2007, poverty has declined 38% and extreme poverty has declined 47%, with vast improvements in health care access and increased enrollment for primary education (Weisbrot 2017). While many social indicators have improved, Correa was also openly hostile to environmental justice advocates and organizations arresting several individuals on dubious charges and shutting down organizations for causing social unrest (Cardenas, Jaramillo, and Nasimba 2011). Ecuador's biological and cultural diversity creates a highly heterogenous socio-ecological landscape rich with local knowledge and natural resources while facing oppressive histories and current realities of women, indigenous groups, and environmental activists.

Data Collection

Field research consisted of identifying potential case studies, selecting case studies, and then collecting and analyzing data for each case study. I identified potential case studies by contacting colleagues and friends from my previous experience in Ecuador. I selected two case studies to test my framework based on the following criteria: 1) the projects aimed to better understand coupled human-environmental systems; 2) the projects were either ongoing or had been completed; and 3) local participants and scientists collaborated to generate new knowledge about the environment. These two case studies were: 1) climate change monitoring network and 2) Andean bear monitoring. With these criteria, the case study project design and protocols were developed, some data were collected, and the project yielded at least preliminary outcomes. Both case studies are ongoing and thus continue to produce outcomes; what is reported here is what was available at the time of my field research.

I conducted field research in Ecuador for two months from July to August 2017. I conducted six (n=6) in-depth semi-structured interviews averaging about 45 minutes each, four in Spanish (Climate Change Monitoring Network case study) and two in English (Andean bear Monitoring case study). The CDO (context, project design, and outcomes) framework guided my questions (see Appendix), but using a semi-structured technique, allowed me to follow-up on leads while also giving interviewees the freedom to express themselves. I interviewed two men and four women. I recorded four interviews using an audio recording device, conducted four interviews in person and two via Skype. For the Climate Change Monitoring case study, I interviewed two scientists and two local participants, and for the Andean bear Monitoring, I interviewed two scientists. For both case studies, I analyzed publications and theses that resulted from the participatory project. In the climate change monitoring case study, I conducted participant observations to see how data was collected and observe how the results were presented to the various participating communities.

Data Analysis

I transcribed recorded interviews in their original language using express scribe transcription software and coded in English in Dedoose 8.0.31 using a combination of deductive-inductive approaches (Braun and Clarke 2006; Hsieh and Shannon 2005); here, deductive references the theory-driven coding system based on the developed CDO framework, and inductive references how codes are added through the process of content analysis. Direct quotes were used to highlight various themes from the interview, however per the IRB protocol, the quotes are anonymous.

Limitations

This study has several limitations in terms of applying the CDO framework and conducting the fieldwork. I developed the CDO framework in an iterative process and therefore the proposed framework was initially simplified at the beginning of the field research, which shaped the questions I asked and the observations I had for each case study. As a result, the context, design, and outcome I describe for each case study were also shaped by the simplicity of my initial framework. I relied on self-reporting through interviews and analyzing publications and participant observation to describe each parameter of the CDO framework. Due to the small sample size (n=6), it is likely that I did not hear all views regarding the outcomes of these projects. Also, the time I spent with participants was limited, which limited my ability to establish good rapport and ironically led to participant perspectives and voices being underrepresented in my analyses of the participatory approaches. However, this led to an important observation regarding the use of my framework, suggesting that it may be best for practitioners to gain insight by considering the outcomes of the participatory projects in which they are involved, rather than using outside consultants in evaluation type processes.

CHAPTER V

CASE STUDY: CLIMATE CHANGE MONITORING NETWORK

The first case study was a participatory project that began as a workshop to train community members in environmental monitoring techniques and resulted in a three-year weather monitoring network that is still ongoing today. Local participants representing various communities within and adjacent to the El Ángel Ecological Reserve in northern Ecuador that were concerned about climate change co-created the project with support from the Quito-based NGO, Corporación Grupo Randi Randi (CGRR), with funding from the MacArthur Foundation. CGRR is an Ecuadorian non-profit founded in 2000 with a vision of sustainable and equitable development through the lens of gender. Their mission is to promote conservation of natural resources, sustainable development, and social and gender equity. CGRR conducts research and technical assistance in communities and local organizations located in threatened ecosystems throughout Ecuador. "Randi Randi" is Kichwa for "giving and giving," which embeds the concept of reciprocity in the work they do. They offer their knowledge and skills knowing that communities will then share their knowledge and skills and thus builds collaborative learning opportunities that strengthen socioecological resilience. Community members collected daily weather data and combined that data with their own experiences to better respond to a changing climate. Using the CDO framework, I explore the context, design, and outcomes of the project (as summarized in Table 1). Both gender roles and the model of engagement were key in shaping outcomes in this case study.

Context

The ecological context of this project faces two primary human-nature gaps: agriculture/conservation land-use tensions and climate change. The agricultural/conservation land-use tensions have both ecological and social dimensions. Ecologically, cultivated areas and natural areas have different hydrological and biological attributes (Buytaert et al. 2006). Socially, there is a distinction between groups with agricultural versus conservation priorities. Local agrarian communities use the land as a primary source of income as well as for subsistence farming (MAE 2015), while national and international conservation priorities aim to protect biodiversity and ecosystem services provided by natural systems. El Ángel Ecological Reserve was established in 1992 and covers over 16,000 hectares. It was established partially in response to the expanding agricultural frontier, which increased by 12% between 1965 and 1993 (López Sandoval 2004). The expanding agricultural frontier conflicted with state and international conservation priorities to protect the unique flora, primarily the frailejones (*Espeletia pycnophyla* subsp. Ángelesis), an endemic sunflower to this region of the paramo, and to protect the headwaters that supply water for the entire Carchi province population (MAE 2015). With the support of CGRR, in 2012 the reserve additionally became protected internationally under the Ramsar treaty, which provides the "framework for national action and international cooperation for the conservation and wise use of wetlands and their resources" (Maibam and Ignat 2014). As an ecological reserve, El Ángel is designated to primarily be used for scientific investigation and environmental education purposes (MAE 2007), but the area is owned and managed (close to 40%) by local agrarian communities. Any management strategy thus requires local community support and is tasked with limiting the burden of conservation priorities that disproportionately fall on people that rely on the land for their livelihoods (Himley 2009).

Further complicating the development of management strategies are the uncertainties and injustices surrounding climate change. Climate change is a manifestation of both the ecological divide and the social divide. Ecologically, through the combustion of fossil fuels, CO_2 increases in the earth's atmosphere, resulting in increases in temperatures and acceleration of the hydrological cycles. Temperatures within the tropical Andes are rising at twice the global average (Vuille et al. 2003) and precipitation is becoming more variable (Morán-Tejeda et al. 2016). Changes in temperatures and precipitation regimes are already affecting aquatic ecologies of lakes within the region (Michelutti et al. 2015) and accelerating glacial retreat (Vuille et al. 2008). Given the topographical complexity of the region and limited monitoring coverage (Padrón et al. 2015), it is unknown how temperature increases will impact natural and cultivated ecosystems or water resource availability at a local level. Climate change also highlights a social divide in that those lifestyles that contribute to climate change are different from those that are being affected by climate change (Althor, Watson, and Fuller 2016; IPCC 2001). Through interviewing community members, CGRR staff reflected during an interview that "The time to plant crops and the time to harvest was much more marked 20 or 30 years ago, now people say it's more difficult to determine."

Social interactions, including race and ethnic relations and gender roles, shape the landscape. The region became inhabited by los Pastos, the indigenous group in Southern Columbia and Northern Ecuador seeking refuge from the Incan Empire in the Western Cordillera of the Andes in Carchi (Santacruz 2009). After Spain colonized the region, the agrarian system shifted to a serfdom called the *huasipungo* system, where large landholders created haciendas and peasant farmers, typically indigenous or lower class mestizos, had rights to very small plots of land but still worked for the hacienda landowners (Rhoades 2006). The hacienda Colada Grande, according to one participant, extended from El Ángel throughout the province. A series of land reforms starting in the 1930s and resurging again in the 1960s broke up the land owned by the hacienda and redistributed it among the peasant and indigenous populations (Himley 2009); however, land titles were typically only provided to the men (Radcliffe 2014). In addition to land access, the division of labor is also highly gendered in rural areas. Women are primary caretakers of the home and children and men engage in income generating activities. As part of a typical daily routine, women start their days earlier than men to milk the cows and prepare breakfast, and they tend to continue doing household chores even after the men retire for the evening.

Design

The ecological and social contexts shaped the project design in terms of the purpose, participation, and process. The current network of meteorological stations managed by INAMHI (National Meteorological Agency of Ecuador) is too granular to be of much use in this highly variable topographically complex region, as shown from the variable results across a relatively short spatial extent. Meteorological stations are expensive to install and maintain. By collecting their own data using simple tools (thermometer and rain gauge), communities cost-effectively gather the data they need to plan and protect their community. The purpose of the monitoring project emerged from a larger international initiative called "Comunidades de los páramos" with support from the International Union for Conservation of Nature (UICN) and MacArthur, and was carried out between 2013 and 2016 in Columbia, Ecuador, and Perú. Within Ecuador, other organizations studied communities throughout Chimborazo and Imbabura, while CGRR carried out the project in Carchi with communities located near the El Ángel Ecological Reserve. The project aimed to build skills for adapting to climate change and to improve páramo conservation. They planned a course to form *promotores comunitarios* or community promoters to discuss how climate change was impacting communities. From that course emerged a protocol to measure the weather. The Ministerio de Medio Ambiente, CGRR and the local communities together updated the El Ángel management plan to include a focus on climate change. They were in the process of searching for climate information and local climate change impacts, but found local information to be severely lacking. The focus of this project was to understand the páramo through the eyes of the communities that lived there rather than only focusing on the biophysical (personal communications with CGRR staff). The climate change monitoring project emerged out of two courses CGRR offered on environmental monitoring and statistics. Participants in these courses noted that they wanted to continue to collect weather data at their homes. The aims were to collect daily temperature and precipitation data, identify climate change risks based on the data and previous experiences, and eventually develop stewardship strategies to both respond to climate change and protect their livelihoods. One participant described the purpose as follows:

> From my point of view, it is with this information we already have started from three years ago, we can see how the climate is changing every year - that heavy rains and intense sun - and in that respect we can prepare for the next year, sowing the crops and preparing the pastures to prevent losses both in the crops as well as economic losses for us.

The participation component includes participants, their motivation, and a co-created model of engagement (as defined by Shirk et al. 2012). Participants include CGRR, the Ministry of the Environment (MAE), and the local participants representing three communities: Eloy Alfaro, Jesus del Gran Poder, and San Sidro. The MAE coordinates the El Ángel management plan and collaborates with CGRR and local community members. Some participants in the Climate Change Monitoring Network are also volunteers for MAE. One participant noted that they monitor the páramo, report fires and share their knowledge about the ecosystem with other community members: “my role is to make people aware that the páramo is life, everything from the water for our families to sustaining the environment.” MAE and CGRR coordinate efforts in order to avoid participant fatigue. CGRR staff noted that this project was successful in part due to the timing: “Sometimes the people get tired of participating in courses and collaborating with NGOs, but this course was during a time when there was a lull in work with other organizations, so people were available to participate.” The project started with 11 participants (6 female, 5 male) that volunteered to co-create the project. The participants represent three communities, Eloy Alfaro, Jesus del Gran Poder, and San Sidro as well as four organizations that were linked to the El Ángel Ecological Reserve, Asociación San Luis, Comuna de Indigenas Pasto la Libertad, Comunidad Palo Blanco and Comunidad Chitacaspi. Men and women representing these organizations formed the *Registro Climatico en nuestra comunidad*, the climate change monitoring network. This network of community participants was part of a larger collective concerned with climate change adaptation.

Local members were motivated to participate in this project both to protect their livelihood and to foster the relationship they have with CGRR. “My role is to move my community forward” recounted one participant, also adding, “We don’t have sufficient weapons to face climate change.” Both participants that I interviewed and the two CGRR staff noted the importance of learning more practical knowledge of land management practices to prepare for climate change. “We’re always ready to collaborate because everyone benefits, we benefit and our nature, our ecosystem benefits too.” Both participants also noted that maintaining their relationship with CGRR was important to them: “We get along really well. Most of all, I consider myself their friend and I have collaborated as you already know because we are working equally for the benefit of the community." They particularly recognize the Director Susan Poats, who has worked with these communities in several projects. One participant stated, "We work because this is her work, this is the love she has for our communities…" Another stated, "She's a fundamental pillar of this campaign." In addition to protecting their livelihoods or strengthening their relationships with CGRR, one comment alluded to a sense of pride and belonging to a place: "I continue to participate for my community and for the communities that surround ours."

Both the purpose and participation influence how the project functions, including the processes of data collection, validation and analysis as well as how participants communicate with one another. During the workshops that CGRR organized in the beginning of 2015, the facilitators, i.e., two staff members from CGRR, demonstrated how to use rain gauges and thermometers to measure precipitation and temperature, respectively. CGRR agreed to support participants by purchasing the thermometers and rain gauges, training participants on how and where to install the equipment, and designing a data sheet with participant input where they could register weather data. CGRR assisted in locating appropriate monitoring sites that were both safe and accessible for installing the equipment. Thermometers (mercury-free maximum-minimum) were located in shaded areas 1.5 to 2 meters above the ground, typically installed on the outside wall of the house. Rain gauges were installed in open areas 1.5 m above the ground and fastened to a wood post. This opportunity was open to anyone that wanted to participate, and participants could stop volunteering as any time.

The first five months (April to August) of the initiative was dedicated to training and learning in an iterative process to practice the methods, use the equipment, and note weather indicator observations. One participant explained that they noted precipitation (in mm) every day at 6am and registered temperature data (in °C) three times a day: morning, afternoon, and evening. As they began collecting data, participants noted that rain type and other weather indicators were becoming more variable. CGRR, accounting for this observation, added additional weather indicators: clear skies, cloudy, heavy rainfall, strong winds, sleet/hail, fog/mist, and freezes. Lastly, participants noted the impacts of these indicators within three distinct zones: conservation zones (natural non-crop vegetation), agricultural zones, and households (typically where the family farm was located). While monitoring is continual, raw data are only periodically validated, synthesized, and analyzed. One participant explained that the community members of the climate monitoring network would meet once a month to discuss the data they collected and compare results. I later found out that this was much less frequent, but the intention was there to meet on occasion to discuss results. This also provides an opportunity for participants to discuss any challenges or uncertainties, as well as remind them that they are part of a network rather than working in isolation.

In addition to sharing results with each other, CGRR also transcribes the data collected manually into excel spreadsheets and shares that data with MAE. CGRR staff analyzes and interprets the data for community members. Given their more formal educational training, they are also more adept in validating the data. In one instance, CGRR staff noted temperature outliers from one participant. They were indicating temperatures near 30°C, which given the altitude and known historical data in the region, seemed inaccurate. Staff used this as a teaching moment and when they shared the results with that participant, asked them what they thought about 30°C. The participant noted that it seemed too high and agreed that it is never that warm where they lived. Together, they checked the thermometer and found that where it was installed may have influenced these high temperatures. They located a different area and reinstalled it, and further explained that if they are still getting high temperatures then there might be something wrong with the equipment and that they would have to replace the thermometer. CGRR staff used this moment to teach how important it is that your data makes sense to you. Just because the thermometer reads a certain value, this does not automatically mean that the value is accurate. They encouraged participants to trust the knowledge they had and to let that guide them in determining whether the numbers they were collecting were reliable.

Outcomes

Context and project design both interact and to create individual, social, and ecological outcomes that correspond to land-use tensions and climate change. Outcomes start at the individual level, influencing interactions at social and ecological levels. At an individual level, members became more aware of weather patterns: "Before I didn't notice. Now it's a habit, I wake up and ask what's going on outside?" They developed skills in data collection, generated knowledge, and learned about the weather and potential risks the community faces within the context of climate change.

At a social level, community participants, CGRR staff and government agencies developed and strengthened relationships. Through these relationships, the knowledge generated from the project was shared to increase collaborative and periphery learning. CGRR staff shared their disciplinary expert knowledge and community members shared the data they collected and their place-based expert knowledge. Periphery learning occurs when participants transfer knowledge to family and friends that did not directly participate in the project, but instead learned about it through having contact with the participants. Gender seems to play a role in knowledge transfer. During the site visits, I observed the meetings where project findings were shared with community members. In the community San Sidro, where only women collected data, only women attended the meeting; on the other hand, in the Jesus de Gran Poder, where the data collector and community president were male, both men and women attended the final meeting. Both participants mentioned sharing the project with others. The male participant discussed the project with other men during soccer games. The other participant explained that a professor from a local university, UNIANDES (*Universidad Regional Autonoma de los Andes*), became interested in the project and wanted to replicate it in other communities throughout Ecuador. Because the community had the data, they were able to leverage it to potentially collaborate with other institutions. To date, this has not resulted in another collaboration to my knowledge.

As of writing this paper, no direct stewardship practice has yet emerged from collecting weather data. In the next stage of the project, participants hope to use the data they collect to develop a management strategy to adapt to and mitigate the effects of climate change. However, the project facilitated contacts with agro-ecological specialists and as a result of that connection, one participant acknowledged altering his stewardship practice on his land to incorporate agro-ecological practices. Through participating in this project, some participants attended training with Pacho Gangotena, one of the most famous Ecuadorian organic farmers, who established his farming practice as a form of resistance to the green revolution, which surged in the 1970s with agricultural practices relying heavily on expensive machinery and fossil fuels (Intriago et al. 2017). One participant recounted that he has incorporated these lessons in his home garden and at his mom's house, a plot of land about 500 to 600 m^2. Specifically, he planted native plants and no longer brings his cattle to the river, rather he brings water to the cattle, which reduces direct contamination to the rivers, increases local biodiversity, and provides wind breaks that protect cattle.

CHAPTER VI

CASE STUDY: ANDEAN BEAR MONITORING

In this case study, the framework is applied to an Andean bear monitoring project that emerged out of community member concerns regarding human-wildlife tensions. The Fundación Cordillera Tropical (FCT) collaborated with communities near Sangay National Park, the local hydroelectric plant HydroPaute, the Ministry of the Environment, and the Carnivore Coexistence Lab to share and generate knowledge on the Andean bear and how to manage human-wildlife conflict in the region. In this case study, the social context and underlying gender roles in particular shaped the design and outcomes of the project (Table 1).

Context

The primary ecological divide represented in this case study stems from land-use tensions between cattle raising and biodiversity protection. Communities nestled along the southern edge of Sangay National Park, commonly referred to as “El Nudo de Azuay,” maintain a rural lifestyle of farming and animal husbandry. Their remoteness and proximity to the park have left their livelihoods vulnerable to human-wildlife conflicts, namely by Andean bears (*Tremarctos ornatus*) attacking and killing cattle or eating crops such as corn (Suarez 1988). Meanwhile, extending pasture land has reduced the bear habitat (Velez–Liendo, Adriaensen, and Matthysen 2014) and changed the local hydrology (Buytaert et al. 2006).

Socially, these land-use tensions pit campesino land-use priorities against the Ministry of the Environment, which strives to uphold the 2008 constitution granting nature rights to survive and thrive. Additionally, HydroPaute generates electricity for the region, which requires steady flows provided by the natural vegetation (Crespo et al. 2011), and also protects the headwaters.

Embedded in these land-use priorities are also social divides related to race, education, and class, as well as highly differentiated gender roles, all of which influence how community members, FCT staff, MAE staff and power plant workers interact. During this time, campesino men were moving disproportionately to the U.S. and other urban areas to seek income generating opportunities, while women remained in the rural communities to take care of the home and raise children.

Design

This project emerged from the socio-ecological context where community members sought support in managing conflicts with the Andean bear. The purpose of this project was to generate knowledge on Andean bear behavior and management strategies to reduce conflict.

Throughout the duration of the project, participation expanded to include various stakeholders, each with distinct motivations that shaped the model of participation. Through a contractual arrangement, community members reached out to the FCT staff to help them develop human-bear conflict mitigation strategies. Through a collaborative process with the community members, FCT staff noted opportunities to better understand Andean bear behavior and enlisted expertise from the Carnivore Coexistence Lab, funding from HydroPuate, activity alignment from the Ministry of the Environment and hired community park guards.

The purpose and participation of various stakeholders influences the processes of data collection, validation and analysis, as well as communication pathways. The FCT began by collaborating with the Carnivore Coexistence Lab from the University of Wisconsin-Madison, and in August of 2007 hosted a workshop with 57 Ecuadorian landowners to discuss human-wildlife coexistence (Treves, Wallace, & White, 2009). Through a collaborative process, stakeholders identified various appropriate interventions that met the needs for conservation and cattle protection. At the end of the workshop, they had established a direct line of communication between landowners and FCT, where FCT would respond anytime the community reported a bear attack. FCT would send staff to listen and emotionally support the landowner's losses.

Listening enabled staff to better understand the situation from their perspective, while validating their feelings helped soothe and possibly prevent retaliatory hunting. While the loss of one cattle was substantial for family members, it became clear that bear attacks were rare. Often cattle loss was due to stray dog attacks or tumbling down cliffs. On average, it might happen once in a family's lifetime. When a bear attack had occurred in the past, cattle were grazing in pastures far from human settlement (4 hrs away by foot, typically). One of the immediate interventions was to encourage landowners whenever possible to bring their cattle closer the home since bear usually stay clear. Over the years, many families have moved their cattle closer to home, but this may not have been a direct result of FCT intervention.

Outcomes

Throughout the last few decades, demographic shifts resulted in stewardship changes that could in part account for the possible decrease in bear attacks. Men between the ages 15 and 60 migrated from these rural settlements in search of work. Many immigrated to the U.S. just outside of New York City, others to Spain, while others moved to urban centers within Ecuador, namely Cuenca, Quito, and Guayaquil. Men traditionally took care of the cattle, but with the depleting labor force, women took on that additional work. This demographic shift resulted in stewardship changes since women tended to keep their livestock closer to home given their role as primary caretakers and home providers. With cattle less likely to be isolated, there were less opportunities for bear attacks. Bringing cattle closer to human settlements is one of the interventions discussed during the workshop, but the stewardship shift was most likely a result of changing gender roles and not an outcome of the collaborative process.

The FCT played an essential role in transferring knowledge among scientists, local environmental officials, and local community members, as well as aligning activities that met the goals of all stakeholders. Concurrently, changes in human demographics altered the social and environmental dimensions of the landscape, and while it might be useful for conservation, had led to challenges for local families. While FCT did not explore social implications of human migration specifically, their aim at creating income-generating activities that align with conservation has led to local people considering new approaches. An FCT staff member recounts one evening visiting the family of a park guard. They were sitting around the table and talked at length about the Andean bear. The younger sister of the park guard, having also gone through the FCT education program, declared that she wanted to study through high school so that she too could become a park guard and became the first female to do so. Change is slow in complex systems, but through human-to-human interaction, sharing knowledge and building trust, here we are beginning to see a shift in the system towards human-wildlife coexistence.

FCT began the community park guard program, viewing it as an opportunity for local engagement, especially since the Ministry of the Environment at the time lacked the resources to hire park guard themselves. Eventually, the Ministry of the Environment began hiring park guards, and two of the community park guards satisfying the minimum education requirements were hired directly by the Ministry, while the other eight park guards continue to function independently. These changes also altered the relationships among the park guards and FCT. FCT staff would go to the field expecting to work with the community park guards to find them working on FONAPA (*Fondo del agua para la conservation de la cuenca de rio Paute*) initiatives. These competing priorities limited how the FCT and community park guards could collaborate and it was a difficult transition for the FCT staff; however, everyone involved also had confidence that these changes would bring new opportunities to collaborate in different ways. In fact, the guards are now a separate entity, sometimes competing with FCT for conservation projects (this knowledge was obtained from personal communications with the current FCT director). The FCT director used the term "competing" playfully, acknowledging that the two groups were now equals. While the relationship between the FCT and the park guards has changed since the community park guards were part of FCT, they still hold each other in high regard, and when the opportunity presents itself they are able to collaborate on projects and support each other when their project objectives align.

This project tells an evolutionary story from participants initially engaging in a more contractual participatory approach to a more collegial effort; that is, community park gaurds are now an independent entity of the NGO and collaborate alongside the NGO, participating in conservation and monitoring work. This case study exemplifies how building relationships is essential to knowledge transfer. This project is not only a story of collaboration between scientists and nonscientists, but it also exemplifies how collaboration among various disciplines function to solve issues related to complex human-wildlife interactions. Social scientists focused on the social aspects, while wildlife biologists focused on Andean Bear health. Social scientists then were able to interpret the knowledge generated by scientists and weave in place-based knowledge to develop an educational curriculum that taught reading comprehension, writing, math, and science. The Andean bear project highlights the importance of interdisciplinary work, which leads to generating the necessary knowledge and transferring that knowledge to all stakeholders that are a part of the socio-ecological system.

This project has been ongoing for ten years, showing how slow long-term environmental and social change can be, how these interventions do not have quick fixes, and how addressing broken relationships takes time to heal; in fact, all of these may require building new relationships and sometimes even new identities. Establishing these relationships enabled more fluid transfer of knowledge, which then continued to support participatory approaches and to some degree leveled the power differential between NGOs and community park guards. The current director explained that now they compete for conservation projects funded by the HydroPaute, providing good-natured competition. In fact, they often collaborated, seeing each other as allies in the work that they do.

CHAPTER VII

CONCLUSION

The CDO Framework facilitated a better understanding of participatory approaches. The multi-tiered design enabled me to analyze the particularities and generalities of each case study. By exploring the higher-level tiers, academics and practitioners can compare various projects. Table 1 compares both case studies, making the similarities and differences in terms of context, design, and outcomes more apparent.

Table 1: Case study overview using the CDO framework.

Framework parameter		Case 1: Climate change	Case 2: Andean bear
Context	Ecological	Agricultural/land-use tensions, climate change impacts	Agricultural/land-use tensions, human-wildlife tensions
	Social	Gender roles important	Gender roles important
Design	Purpose	Management and science	Management and science
	Motivation	Improve livelihoods, relationship building	Improve livelihoods, generate knowledge about wildlife
	Model of engagement	Co-created	Contractual initially, collegial in the end
Outcomes	Ecological	Agroecological practices	Livestock management practices
	Social	Collective and peripheral learning, relationship building	Collective and peripheral learning, relationship building
	Individual	Increased awareness, knowledge and skills	Increased awareness, knowledge and skills, increased income

Both case studies faced land-use tensions between agriculture and conservation, and participation was partly shaped through various social divides. Gender in particular was important in both case studies. In the Climate Change Monitoring Network case study, gender influenced how knowledge was transferred. In the Andean bear Monitoring case study, shifts in gender roles led to the shift in management practices, which reduced the number of bear attacks and encouraged FCT to further study the Andean bear through various partnerships. Men were selected to be para-biologists for two reasons: 1) women lacked the education level and 2) pairing a man and woman together to work as a team in the field would have been culturally inappropriate. While the framework identified gender as an important component, further research should explore how gender relations underlie each case study in more detail.

Participants in both cases were motivated to improve their livelihoods, and both resulted in participants gaining knowledge and skills and then sharing that knowledge with others, which led to changes in management practices. Differences included the model of participation; specifically, the climate change project was co-created and the Andean bear project shifted from contractual to collegial. This shift to a collegial model also resulted in increased income for para-biologists in the Andean bear project. Model selection will vary from project to project, but should align with participant motivation and skills, as well as the purpose of the project. I suggest that if there are more participant livelihoods at stake, then participant involvement should be considered as more important.

In both case studies, collaboration between the NGOs and local communities had been established prior to each project. When an organization has been collaborating in an area for a long time, each project builds on the previous project and it is difficult to attribute outcomes to a specific effort since they tend to be a culmination of efforts and since ecological and social outcomes occur at different time and spatial scales. The proposed framework would benefit by more explicitly integrating history into the context.

Power dimensions also warrant a more in-depth study in both cases. In the climate change project one participant shared why collaborating with NGOs or other institutions is important. One participant said:

> *Nosotros no somos suficiente para decir que vean lo que hicimos tal vez lo que nosotros aquí en la comunidad alguien no nos hace caso. Pero tal vez a través a otra persona que vea esto resultado el dice yo quiero esto porque quiero hacer un proyecto aquí y con esto de lo que ustedes tienen lo podemos hacer.*
>
> Maybe we are not sufficient to tell people, maybe other people won't pay attention to us, but maybe through another person (referring to the professor from UNIANDES) that sees this result he says I want to do a project here and with what you have done we can do it.

I have heard similar comments where campesinos downplay their own autonomy and self-efficacy to build up the institution with whom they are collaborating. Power dimensions in cultures with high power distance such as what we see in Ecuador may help practitioners more adequately address power disparities in participatory projects.

The CDO framework was effective in analyzing participatory approaches that generate knowledge about the ecological divide. The framework allows analysis on multiple levels, thus enabling academics and practitioners to visualize how context and project design interact to create outcomes, which may in turn assist in developing strategies moving forward.

APPENDIX

SAMPLE QUESTIONS

Sample Interview Questions for Lay Participants.

Esta entrevista debe demorar entre 30 y 60 minutos. Como esta explicado en el formulario de consentimiento, la entrevista es completamente por su voluntad es decir que puede parar o ir fuera de registro en cualquier momento. Le agradezco por su participación.

(*This interview should take between 30 and 60 minutes. As outlined in the consent form, it is completely voluntary and we can stop at any time or go off the record. Thank you for your participation!*)

1) Por favor declare su nombre, edad, profesión, y por cuanto tiempo ha vivido en [nombre de comunidad/bario]. *(Please state your name, age, occupation, and how long you have lived or worked in [name of community/neighborhood].)*
2) Antes de que el proyecto comenzara, ¿Cómo habría descrito su comunidad/bario? *(How would you have described your community/neighborhood before the project started?)*
3) Cuáles fueron algunos de los problemas que se enfrentó su comunidad/barrio? ¿Y cómo se les estaba abordando? *(What were some of the problems your community/neighborhood faced? And how were they being addressed?)*
4) Cuéntame sobre la historia de proyecto y como fue previsto. *(Tell me about how the citizen science project was started.)*
5) ¿Cuándo y cómo se involucró usted? *(When and how did you get involved?)*
6) ¿Inicialmente, por qué quería participar? *(Why did you initially want to participate?)*

7) ¿Y ahora? ¿Por qué sigas participando? (*Is this different than why you participate now?)*

8) ¿Cuál es su rol en el proyecto? ¿Qué hace usted? (*What is your role in the project? What do you do?)*

9) ¿Cuáles son los objetivos del proyecto? (*What do you think the goals of the project are?)*

10) ¿Qué pasa con la información una vez recolectada? (*What happens to the information you collect?)*

11) ¿Usted sabe cómo la información esta utilizada? (*Do you know how it is used?)*

12) ¿Cómo se llaman los científicos quien les han visitado? *(What are the names of the scientists that have visited the community?)*

13) Me podría describir la interacción entre usted (o la comunidad) y los científicos. (*Describe your interaction with the scientists.)*

14) Cuéntame sobre un momento en lo que pensaba (usted u otro miembro de la comunidad) diferente de lo que pensaban los científicos, ¿qué pasó? (*Tell me about a time you thought differently than what the scientists thought, what happened?)*

15) ¿Los demás vecinos o miembros de la comunidad quien no están directamente involucrados en el proyecto le preguntan a usted sobre el proyecto? (*Do other neighbors/community members ask you about the project that are not directly involved?)*

16) (si sí) ¿Qué les dice? (*(if yes) What do you tell them?)*

17) Antes de participar en este proyecto, ¿Qué pensó usted acerca de [insertar el concepto en el que se centra el proyecto]? (*Before being involved in this project, what did you think about [insert concept that project is focused on].)*

18) ¿Es diferente de cómo piensa en ello ahora? (*Is that different from how think about it now?)*

19) ¿Qué aprendió a través de participar en este proyecto? (*What have you learned by participating in this project?)*

20) ¿De qué le gustaría aprender más? ¿Qué preguntas tiene usted? (*What would you like to learn more about? What questions do you have?)*

21) ¿Cómo ve el proyecto avanzando? *(How do you see the Project moving forward?)*

22) ¿Tiene alguna pregunta para los científicos? (*If you could ask the scientists anything, what would you ask?)*

23) ¿Hay algo más que usted le gustaría decir sobre esta experiencia? (*Is there anything else you would like to add?)*

Sample Interview Questions for Professional Scientists.

Esta entrevista debe demorar entre 30 y 60 minutos. Como esta explicado en el formulario de consentimiento, la entrevista es completamente por su voluntad es decir que puede parar o ir fuera de registro en cualquier momento. Le agradezco por su participación. (*This interview should take between 30 and 60 minutes. As outlined in the consent form, it is completely voluntary and we can stop at any time or go off the record. Thank you for your participation!*)

1) Por favor declare su nombre, edad, profesión, y por cuanto tiempo ha trabajado en el proyecto. (*Please state your name, age, occupation, and how long you have worked with the project.)*

2) Antes de que el proyecto comenzara, ¿Qué sabía usted del área de estudio y de las personas que vivían allí? (*Before the project started, what did you know about the study area and the people that lived there?)*

3) Cuéntame sobre la historia de proyecto y como fue previsto. *(Tell me about how the citizen science project was started.)*

4) ¿Cuándo y cómo se involucró usted? (*When and how did you get involved?)*

5) ¿Inicialmente, por qué quería participar? (*Why did you initially want to participate?)*

6) ¿Y ahora? ¿Por qué sigas participando? (*Is this different than why you participate now?)*

7) ¿Cuál es su rol en el proyecto? ¿Qué hace usted? (*What is your role in the project? What do you do?)*

8) ¿Cuáles son los objetivos del proyecto? (*What do you think the goals of the project are?)*

9) ¿Qué pasa con la información una vez recolectada? (*What happend with the information that is collected?)*

10) ¿Cómo esta analizada? *(How is it analyzed)*

11) ¿Para que esta utilizada? *(For what is it used?)*

12) ¿Conoces los sitios del estudio y los voluntarios? *(Have you been to the study sites? Have you met the volunteers?)*

13) Me podría describir la interacción entre usted y los voluntarios. (*Describe your interaction with the lay participants.)*

14) Cuéntame sobre un momento en lo que pensaba (usted u otro científico) diferente de lo que pensaban los voluntarios, ¿qué pasó? (*Tell me about a time you thought differently than what the lay participants thought, what happened?)*

15) ¿Qué ha aprendido personalmente sobre el área de estudio? (*What have you learned personally about the study area?)*

16) ¿Cuáles son los hallazgos principales hasta ahora? (*What are some of the main findings to date?)*

17) ¿Cuál de los hallazgos no habría sido posible si no fuera por el enfoque de la ciencia ciudadana? (*Which of those might not have been possible if not for the citizen science approach?)*

18) ¿Cómo ve el proyecto avanzando? (*How do you see the project moving forward?)*

19) ¿Ha hablado con otros que no están directamente involucrados en el proyecto? ¿Con quién y qué les dice? (*Do you talk to others not directly involved about the project? With whom and what do you say?)*

20) Si pudieras preguntar algo a los participantes, ¿qué preguntaría? (*If you could ask the lay participants anything, what would you ask?)*

21) ¿Hay algo más que usted le gustaría decir sobre esta experiencia? (*Is there anything else you would like to add?)*

REFERENCES CITED

Almeida Castanho, Andrea D. de, David Galbraith, Ke Zhang, Michael T. Coe, Marcos H. Costa, and Paul Moorcroft. 2016. “Changing Amazon Biomass and the Role of Atmospheric CO_2 Concentration, Climate, and Land-use: CHANGING AMAZON BIOMASS.” *Global Biogeochemical Cycles* 30 (1): 18–39. https://doi.org/10.1002/2015GB005135.

Althor, Glenn, James E. M. Watson, and Richard A. Fuller. 2016. “Global Mismatch between Greenhouse Gas Emissions and the Burden of Climate Change.” *Scientific Reports* 6 (1). https://doi.org/10.1038/srep20281.

AméZquita, Adolfo, Roberto MáRquez, Ricardo Medina, Daniel MejíA-Vargas, Ted R. Kahn, Gustavo SuáRez, and Luis Mazariegos. 2013. “A New Species of Andean Poison Frog, *Andinobates* (Anura: Dendrobatidae), from the Northwestern Andes of Colombia.” *Zootaxa* 3620 (1). https://doi.org/10.11646/zootaxa.3620.1.8.

Anderies, John M., Marco A. Janssen, and Elinor Ostrom. 2004. “A Framework to Analyze the Robustness of Social-Ecological Systems from an Institutional Perspective.” *Ecology and Society* 9 (1). https://doi.org/10.5751/ES-00610-090118.

Arellano, Paul, Kevin Tansey, Heiko Balzter, and Markus Tellkamp. 2017. “Plant Family-Specific Impacts of Petroleum Pollution on Biodiversity and Leaf Chlorophyll Content in the Amazon Rainforest of Ecuador.” Edited by Jinxing Lin. *PLOS ONE* 12 (1): e0169867. https://doi.org/10.1371/journal.pone.0169867.

Arnstein, Sherry R. 1969. “A Ladder Of Citizen Participation.” *Journal of the American Institute of Planners* 35 (4): 216–24. https://doi.org/10.1080/01944366908977225.

Ballard, Heidi L., and Jill M. Belsky. 2010. “Participatory Action Research and Environmental Learning: Implications for Resilient Forests and Communities.” *Environmental Education Research* 16 (5–6): 611–27. https://doi.org/10.1080/13504622.2010.505440.

Becker, Marc. 2012. “Building a Plurinational Ecuador: Complications and Contradictions.” *Socialism and Democracy* 26 (3): 72–92. https://doi.org/10.1080/08854300.2012.710000.

Berkes, Fikret, Johan Colding, and Carl Folke. 2000. “Rediscovery of Traditional Ecological Knowledge as Adaptive Management.” *Ecological Applications* 10 (5): 1251–62. https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2.

Berkes, Fikret, Carl Folke, and Johan Colding, eds. 1998. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge, U.K. ; New York, NY, USA: Cambridge University Press.

Black Elk, Linda. 2016. "Native Science: Understanding and Respecting Other Ways of Thinking." *Rangelands* 38 (1): 3–4. https://doi.org/10.1016/j.rala.2015.11.003.

Bonney, Rick, Heidi Ballard, Rebecca Jordan, Ellen McCallie, Tina Phillips, Jennifer Shirk, and Candie C. Wilderman. 2009. *Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report*. Washington, D.C: Centre for Advancement of Informal Science Education. https://eric.ed.gov/?id=ED519688.

Braun, Virginia, and Victoria Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3 (2): 77–101. https://doi.org/10.1191/1478088706qp063oa.

Brown, Valerie A., and Judith A. Lambert. 2013. *Collective Learning for Transformational Change: A Guide to Collaborative Action*. New York: Routledge.

Bullard, Robert D., ed. 1994. *Unequal Protection: Environmental Justice and Communities of Color*. San Francisco: Sierra Club Books.

Butcher, G.S. 1990. "Audubon Christmas Bird Counts." In *Survey Designs and Statistical Methods Forthe Estimation of Avian Population Trends*, edited by J.R. Sauer and S. Droege, 5–13. Washington, D.C., USA: U.S. Fish and Wildlife ServiceBiological Report 90(1).

Buytaert, W., and B. De Bièvre. 2012. "Water for Cities: The Impact of Climate Change and Demographic Growth in the Tropical Andes: CLIMATE CHANGE IMPACTS ON ANDEAN WATER RESOURCES." *Water Resources Research* 48 (8): 1–13. https://doi.org/10.1029/2011WR011755.

Buytaert, Wouter, Rolando Célleri, Bert De Bièvre, Felipe Cisneros, Guido Wyseure, Jozef Deckers, and Robert Hofstede. 2006. "Human Impact on the Hydrology of the Andean Páramos." *Earth-Science Reviews* 79 (1–2): 53–72. https://doi.org/10.1016/j.earscirev.2006.06.002.

Buytaert, Wouter, Zed Zulkafli, Sam Grainger, Luis Acosta, Tilashwork C. Alemie, Johan Bastiaensen, Bert De BiÃ¨vre, et al. 2014. "Citizen Science in Hydrology and Water Resources: Opportunities for Knowledge Generation, Ecosystem Service Management, and Sustainable Development." *Frontiers in Earth Science* 2 (October). https://doi.org/10.3389/feart.2014.00026.

Cardenas, Alejandra Reyes, Leonardo Mora Jaramillo, and Rocío Loachamín Nasimba. 2011. "Los Escenarios de La Criminalización a Defensores Ae Derechos Humanos y de La Naturaleza En Ecuador: Desafíos Para Un Estado Constitucional de Derechos." Quito, Ecuador: Defensoria del Pueblo de Ecuador. http://www.inredh.org/archivos/pdf/escenarios_criminalizacion_defensoresydefensoras.pdf.

Castillo, Luis Carlos, and Heriberto Cairo Carou. 2002. "Reinvención de La Identidad Étnica, Nuevas Territorialidades y Redes Globales: El Estado Multiétnico y Pluricultural En Colombia y Ecuador." *Revista Sociedad y Economía*, no. 3: 55–76.

Ceballos, G., P. R. Ehrlich, A. D. Barnosky, A. Garcia, R. M. Pringle, and T. M. Palmer. 2015. "Accelerated Modern Human-Induced Species Losses: Entering the Sixth Mass Extinction." *Science Advances* 1 (5): e1400253–e1400253. https://doi.org/10.1126/sciadv.1400253.

Célleri, Rolando, and Jan Feyen. 2009. "The Hydrology of Tropical Andean Ecosystems: Importance, Knowledge Status, and Perspectives." *Mountain Research and Development* 29 (4): 350–55. https://doi.org/10.1659/mrd.00007.

Checkland, Peter. 1999. "Systems Thinking." In *Rethinking Management Information Systems: An Interdisciplinary Perspective*, edited by Wendy Currie and Bob Galliers, 45–56. OUP Oxford.

"Christmas Bird Count Bibliography." 2015. Audubon. January 9, 2015. http://www.audubon.org/christmas-bird-count-bibliography.

CIA. 2017. "Ecuador." *The World Factbook* (blog). July 18, 2017. https://www.cia.gov/library/publications/the-world-factbook/geos/ec.html.

Clarke, Tracylee, and Tarla Rai Peterson. 2016. *Environmental Conflict Management*. Thousand Oaks, California: SAGE Publications, Inc.

Cohn, Jeffrey P. 2008. "Citizen Science: Can Volunteers Do Real Research?" *BioScience* 58 (3): 192. https://doi.org/10.1641/B580303.

Collins, H. M., and Robert Evans. 2007. *Rethinking Expertise*. Chicago: University of Chicago Press.

Conrad, Catherine T., and Tyson Daoust. 2008. “Community-Based Monitoring Frameworks: Increasing the Effectiveness of Environmental Stewardship.” *Environmental Management* 41 (3): 358–66. https://doi.org/10.1007/s00267-007-9042-x.

Cooper, Caren B., Jennifer Shirk, and Benjamin Zuckerberg. 2014. “The Invisible Prevalence of Citizen Science in Global Research: Migratory Birds and Climate Change.” Edited by Robert Guralnick. *PLoS ONE* 9 (9): e106508. https://doi.org/10.1371/journal.pone.0106508.

Corburn, Jason. 2005. *Street Science : Community Knowledge and Environmental Health Justice*. Urban and Industrial Environments Ser. Place of publication not identified: Place of publication not identified MIT Press.

Crain, Rhiannon, Caren Cooper, and Janis L. Dickinson. 2014. “Citizen Science: A Tool for Integrating Studies of Human and Natural Systems.” *Annual Review of Environment and Resources* 39 (1): 641–65. https://doi.org/10.1146/annurev-environ-030713-154609.

Crespo, Patricio Javier, Jan Feyen, Wouter Buytaert, Amelie Bücker, Lutz Breuer, Hans-Georg Frede, and Marco Ramírez. 2011. “Identifying Controls of the Rainfall–runoff Response of Small Catchments in the Tropical Andes (Ecuador).” *Journal of Hydrology* 407 (1–4): 164–74. https://doi.org/10.1016/j.jhydrol.2011.07.021.

Cuesta, F., and M.T. Becerra. 2009. *Atlas de Los Andes Del Norte y Centro*. Lima, Peru: Secretaría General de la Comunidad Andina. www.condesan.org/portal/sites/default/files/publicaciones/archivos/atlas_andes.pdf.

Cullen-Unsworth, Leanne Claire, Rosemary Hill, James R A Butler, and Marilyn Wallace. 2012. “A Research Process for Integrating Indigenous and Scientific Knowledge in Cultural Landscapes: Principles and Determinants of Success in the Wet Tropics World Heritage Area, Australia: Integrating Indigenous and Scientific Knowledge in Cultural Landscapes.” *The Geographical Journal* 178 (4): 351–65. https://doi.org/10.1111/j.1475-4959.2011.00451.x.

Daniels, Steven E, and G. B Walker, eds. 2001a. “Systems Thinking.” In *Working through Environmental Conflict : The Collaborative Learning Approach*, 99–129. Westport, Conn.: Westport, Conn. : Praeger.

Daniels, Steven E., and Gregg B. Walker. 2001b. *Working through Environmental Conflict: The Collaborative Learning Approach*. Westport, Conn: Praeger.

Danielsen, Finn, Neil D. Burgess, Per M. Jensen, and Karin Pirhofer-Walzl. 2010. "Environmental Monitoring: The Scale and Speed of Implementation Varies According to the Degree of Peoples Involvement: Monitoring: Participation Boosts Action." *Journal of Applied Ecology* 47 (6): 1166–68. https://doi.org/10.1111/j.1365-2664.2010.01874.x.

England, Kim V. L. 1994. "Getting Personal: Reflexivity, Positionality, and Feminist Research∗." *The Professional Geographer* 46 (1): 80–89. https://doi.org/10.1111/j.0033-0124.1994.00080.x.

Escobar, Arturo. 2006. "Difference and Conflict in the Struggle Over Natural Resources: A Political Ecology Framework." *Development* 49 (3): 6–13. https://doi.org/10.1057/palgrave.development.1100267.

Fehr, Carla. 2011. "What Is in It for Me? The Benefits of Diversity in Scientific Communities." In *Feminist Epistemology and Philosophy of Science Power in Knowledge*, edited by Heidi Grasswick. Feminist Epistemology and Philosophy of Science : Power in Knowledge. Dordrecht: Dordrecht : Springer Netherlands.

Fisher, Janet A., Genevieve Patenaude, Kalpana Giri, Kristina Lewis, Patrick Meir, Patricia Pinho, Mark D.A. Rounsevell, and Mathew Williams. 2014. "Understanding the Relationships between Ecosystem Services and Poverty Alleviation: A Conceptual Framework." *Ecosystem Services* 7 (March): 34–45. https://doi.org/10.1016/j.ecoser.2013.08.002.

Follett, Ria, and Vladimir Strezov. 2015. "An Analysis of Citizen Science Based Research: Usage and Publication Patterns." Edited by Stefano Goffredo. *PLOS ONE* 10 (11): e0143687. https://doi.org/10.1371/journal.pone.0143687.

Fraser, Barbara. 2014. "The First South Americans: Extreme Living." *Nature* 514: 24–26.

Funtowicz, Silvio O., and Jerome R. Ravetz. 1993. "Science for the Post-Normal Age." *Futures* 25 (7): 739–55. https://doi.org/10.1016/0016-3287(93)90022-L.

Gareis, Iris. 2005. "Identidades Latinoamericanas Frente Al Colonialismo. Una Apreciación Histórico-Antropológica: Introducción Al Dossier." INDIANA. https://doi.org/10.18441/ind.v22i0.9-18.

Gaston, Kevin J. 2000. *Pattern and Process in Macroecology*. Oxford, OX: Oxford, OX.

Gerlach, Allen. 2003. *Indians, Oil, and Politics: A Recent History of Ecuador*. Latin American Silhouettes. Wilmington, Del: Scholarly Resources.

GFP. 2018. “Earth Overshoot Day.” Global Footprint Network. 2018. https://www.footprintnetwork.org/our-work/earth-overshoot-day/.

Glick, Peter, and Susan T Fiske. 1999. “Gender, Power Dynamics, and Social Interaction.” In *Revisioning Gender*, edited by Myra Marx Ferree, Judith Lorber, and Beth B. Hess, 5:365–398. Rowman Altamira.

Grasswick, Heidi. 2011. *Feminist Epistemology and Philosophy of Science Power in Knowledge*. Feminist Epistemology and Philosophy of Science : Power in Knowledge. Dordrecht: Dordrecht : Springer Netherlands.

Gray, Steven, Alexey Voinov, Michael Paolisso, Rebecca Jordan, Todd BenDor, Pierre Bommel, Pierre Glynn, et al. 2018. “Purpose, Processes, Partnerships, and Products: Four Ps to Advance Participatory Socio-Environmental Modeling.” *Ecological Applications* 28 (1): 46–61. https://doi.org/10.1002/eap.1627.

Hall, Edward T. 1989. *Beyond Culture*. Anchor Books ed. New York: Anchor Books.

Haraway, Donna. 1988. “Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective” 14 (3): 575–99. https://doi.org/10.2307/3178066.

Harcourt, Wendy, ed. 1994. *Feminist Perspectives on Sustainable Development*. London ; Atlantic Highlands, N.J: Zed Books, in association with Society for International Development, Rome.

Harding, Sandra. 1995. “‘Strong Objectivity’: A Response to the New Objectivity Question.” *Synthese* 104 (3): 331–49.

Haywood, Benjamin K., Julia K. Parrish, and Jane Dolliver. 2016. “Place-Based and Data-Rich Citizen Science as a Precursor for Conservation Action: Citizen Science and Conservation Action.” *Conservation Biology* 30 (3): 476–86. https://doi.org/10.1111/cobi.12702.

Healy, Stephen. 2009. “Toward an Epistemology of Public Participation.” *Journal of Environmental Management* 90 (4): 1644–54. https://doi.org/10.1016/j.jenvman.2008.05.020.

Himley, Matthew. 2009. “Nature Conservation, Rural Livelihoods, and Territorial Control in Andean Ecuador.” *Geoforum* 40 (5): 832–42. https://doi.org/10.1016/j.geoforum.2009.06.001.

Hofstede, Geert. 2011. “Dimensionalizing Cultures: The Hofstede Model in Context.” *Online Readings in Psychology and Culture* 2 (1). https://doi.org/10.9707/2307-0919.1014.

Hofstede, Geert H. 1991. *Cultures and Organizations: Software of the Mind*. London ; New York: McGraw-Hill.

———. 2018. “Ecuador.” *Hofstede Insights* (blog). 2018. https://www.hofstede-insights.com/country/ecuador/.

Hohn, Donovan. 2016. “Flint’s Water Crisis and the ‘Troublemaker’ Scientist.” *The New York Times*, August 16, 2016, sec. Magazine. https://www.nytimes.com/2016/08/21/magazine/flints-water-crisis-and-the-troublemaker-scientist.html.

Holling, C. S. 1998. “Two Cultures of Ecology.” *Conservation Ecology* 2 (2). https://doi.org/10.5751/ES-00045-020204.

Hsieh, Hsiu-Fang, and Sarah E. Shannon. 2005. “Three Approaches to Qualitative Content Analysis.” *Qualitative Health Research* 15 (9): 1277–88. https://doi.org/10.1177/1049732305276687.

Hurtig, A.-K. 2002. “Geographical Differences in Cancer Incidence in the Amazon Basin of Ecuador in Relation to Residence near Oil Fields.” *International Journal of Epidemiology* 31 (5): 1021–27. https://doi.org/10.1093/ije/31.5.1021.

INEC. 2010. “VII Censo de Poblacion y VI de Vivieda 2010.” Estadisticas Sociodemograficas. Quito Ecuador. http://anda.inec.gob.ec/anda/index.php/catalog/270.

Intriago, Richard, Roberto Gortaire Amézcua, Elizabeth Bravo, and Chris O’Connell. 2017. “Agroecology in Ecuador: Historical Processes, Achievements, and Challenges.” *Agroecology and Sustainable Food Systems* 41 (3–4): 311–28. https://doi.org/10.1080/21683565.2017.1284174.

IPCC. 2001. “Impacts, Adaptations and Vulnerability - the Contribution of Working Group II to the Thrid Scientific Assessment of the Intergovernmental Panel on Climate Change.” Cambridge: Cambridge University Press.

Irwin, Alan. 1995. *Citizen Science: A Study of People, Expertise, and Sustainable Development*. Environment and Society. London ; New York: Routledge.

Johnston, Barbara Rose, ed. 1994. *Who Pays the Price? The Sociocultural Context of Environmental Crisis*. Washington, D.C: Island Press. Society for Applied Anthropology.

Konrad, K. 2011. “Lois Gibbs: Grassroots Organizer and Environmental Health Advocate.” *American Journal of Public Health* 101 (9): 1558–59. https://doi.org/10.2105/AJPH.2011.300145.

Krasny, Marianne E, and Keith G Tidball. 2012. “Civic Ecology: A Pathway for Earth Stewardship in Cities.” *Frontiers in Ecology and the Environment* 10 (5): 267–73. https://doi.org/10.1890/110230.

Laegaard, S. 1992. “Páramos as a Secondary Vegetation Type.” In *Páramos: An Andean Ecosystem under Human Influence*, edited by H. Balslev and James L. Luteyn, 151–70. London: Academic Press.

Laurance, William F., Jeffrey Sayer, and Kenneth G. Cassman. 2014. “Agricultural Expansion and Its Impacts on Tropical Nature.” *Trends in Ecology & Evolution* 29 (2): 107–16. https://doi.org/10.1016/j.tree.2013.12.001.

Lee, Min-sun, Juyoung Lee, Bum-Jin Park, and Yoshifumi Miyazaki. 2015. “Interaction with Indoor Plants May Reduce Psychological and Physiological Stress by Suppressing Autonomic Nervous System Activity in Young Adults: A Randomized Crossover Study.” *Journal of Physiological Anthropology* 34 (1). https://doi.org/10.1186/s40101-015-0060-8.

Lewis, Tammy L. 2016. *Ecuador’s Environmental Revolutions: Ecoimperialists, Ecodependents, and Ecoresisters*. Cambridge, MA: MIT Press.

López Sandoval, María Fernanda. 2004. *Agricultural and Settlement Frontiers in the Tropical Andes: The Páramo Belt of Northern Ecuador, 1960-1990*. Regensburger Geographische Schriften, Heft 37. Regensburg: Institut für Geographie an der Universität Regensburg.

Luteyn, James L. 1992. "Paramos: Why Study Them?" In *Paramo: An Andean Ecosystem under Human Influence*, by H. Balslev and James L. Luteyn, 1–14. London: Academic Press.

MAE, Ministerio de Ambiente. 2015. "Plan de Manejo de La Reserva Ecologica El Angel." Quito Ecuador. http://suia.ambiente.gob.ec/documents/10179/242256/24+PLAN+DE+MANEJO+EL+ANGEL.pdf/134234ba-a47d-459c-956b-37b0155df002.

MAE, (Ministerio del Ambiente del Ecuador). 2007. "Plan Estratégico Del Sistema Nacional de Áreas Protegidas Del Ecuador 2007-2016." Informe Final de Consultoría. Proyecto GEF: Ecuador Sistema Nacional de Áreas Protegidas (SNAP-GEF). REGAL-ECOLEX. Quito.

Maibam, Dhanaraj, and Helmut Ignat. 2014. "What Is Happening to Wetlands and What Can We Do?" *Ramsar*, 2.

Matsuura, Masahiro, and Todd Schenk. 2017. *Joint Fact-Finding in Urban Planning and Environmental Disputes*. New York: Routledge. http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=1365305.

Merriam, Sharan B., Juanita Johnson-Bailey, Ming-Yeh Lee, Youngwha Kee, Gabo Ntseane, and Mazanah Muhamad. 2001. "Power and Positionality: Negotiating Insider/Outsider Status within and across Cultures." *International Journal of Lifelong Education* 20 (5): 405–16. https://doi.org/10.1080/02601370120490.

Michelutti, Neal, Alexander P. Wolfe, Colin A. Cooke, William O. Hobbs, Mathias Vuille, and John P. Smol. 2015. "Climate Change Forces New Ecological States in Tropical Andean Lakes." Edited by Connie Lovejoy. *PLOS ONE* 10 (2): e0115338. https://doi.org/10.1371/journal.pone.0115338.

Miller-Rushing, Abraham, Richard Primack, and Rick Bonney. 2012. "The History of Public Participation in Ecological Research." *Frontiers in Ecology and the Environment* 10 (6): 285–90. https://doi.org/10.1890/110278.

Mittermeier, Russell A., ed. 2004. *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*. 1. engl. ed. Mexico City: CEMEX.

Mittermeier, Russell A., and Cristina Goettsch Mittermeier. 1997. *Megadiversity: Earth's Biologically Wealthiest Nations*. 1st English ed. México, D.F.: CEMEX.

Moore, Kelly. 2006. "Powered by the People: Scientific Authority in Participatory Science." In *New Political Sociology of Science*, edited by Scott Frickel and Kelly Moore, 299–323. University of Wisconsin Press.

Morán-Tejeda, Enrique, Juan Bazo, Juan I. López-Moreno, Enric Aguilar, César Azorín-Molina, Arturo Sanchez-Lorenzo, Rodney Martínez, et al. 2016. "Climate Trends and Variability in Ecuador (1966-2011): CLIMATE TRENDS AND VARIABILITY IN ECUADOR." *International Journal of Climatology* 36 (11): 3839–55. https://doi.org/10.1002/joc.4597.

Moser, Caroline O. N. 1993. *Gender Planning and Development: Theory, Practice, and Training*. London; New York: Routledge.

Murray, Thomas H. 1983. "Partial Knowledge." In *Ethics, The Social Sciences, and Policy Analysis*, edited by Daniel Callahan and Bruce Jennings, 305–31. Boston, MA: Springer US. https://doi.org/10.1007/978-1-4684-7015-4_13.

Nogué, Sandra, Valentí Rull, and Teresa Vegas-Vilarrúbia. 2013. "Elevational Gradients in the Neotropical Table Mountains: Patterns of Endemism and Implications for Conservation." Edited by Rafael Loyola. *Diversity and Distributions* 19 (7): 676–87. https://doi.org/10.1111/ddi.12017.

O'Brien, L., M. Marzano, and R. M. White. 2013. "'Participatory Interdisciplinarity': Towards the Integration of Disciplinary Diversity with Stakeholder Engagement for New Models of Knowledge Production." *Science and Public Policy* 40 (1): 51–61. https://doi.org/10.1093/scipol/scs120.

Ostrom, Elinor, and Michael Cox. 2010. "Moving beyond Panaceas: A Multi-Tiered Diagnostic Approach for Social-Ecological Analysis." *Environmental Conservation* 37 (04): 451–63. https://doi.org/10.1017/S0376892910000834.

Padrón, Ryan S., Bradford P. Wilcox, Patricio Crespo, and Rolando Célleri. 2015. "Rainfall in the Andean Páramo: New Insights from High-Resolution Monitoring in Southern Ecuador." *Journal of Hydrometeorology* 16 (3): 985–96. https://doi.org/10.1175/JHM-D-14-0135.1.

Paulson, Susan. 2003. "Gendered Practices and Landscapes in the Andes: The Shape of Asymmetrical Exchanges." *Human Organization* 62 (3): 242–54. https://doi.org/10.17730/humo.62.3.62mwrgc45nmym8xy.

———. 2016. *Masculinities and Femininities in Latin America's Uneven Development*. http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=1055286.

Petkova, Diana P. 2015. "Cultural Identity, Collective Self-Image and Religious Consciousness in Ecuador." *Eastern Academic Journal*, no. 4: 20.

Pretty, J., J. Peacock, R. Hine, M. Sellens, N. South, and M. Griffin. 2007. "Green Exercise in the UK Countryside: Effects on Health and Psychological Well-Being, and Implications for Policy and Planning." *Journal of Environmental Planning and Management* 50 (2): 211–31. https://doi.org/10.1080/09640560601156466.

Pulido, Laura. 2015. "Geographies of Race and Ethnicity 1: White Supremacy vs White Privilege in Environmental Racism Research." *Progress in Human Geography* 39 (6): 809–17. https://doi.org/10.1177/0309132514563008.

Radcliffe, Sarah A. 2014. "Gendered Frontiers of Land Control: Indigenous Territory, Women and Contests over Land in Ecuador." *Gender, Place & Culture* 21 (7): 854–71. https://doi.org/10.1080/0966369X.2013.802675.

Reason, Peter, and Hilary Bradbury, eds. 2008. *The Sage Handbook of Action Research: Participative Inquiry and Practice*. 2nd ed. London ; Thousand Oaks, Calif: SAGE Publications.

Rees, William E. 2006. "Ecological Footprints and Biocapacity: Essential Elements in Sustainability Assessment." In *Renewables-Based Technology*, edited by Jo Dewulf and Herman Van Langenhove, 143–57. Chichester, UK: John Wiley & Sons, Ltd. https://doi.org/10.1002/0470022442.ch9.

Resnik, David B., Kevin C. Elliott, and Aubrey K. Miller. 2015. "A Framework for Addressing Ethical Issues in Citizen Science." *Environmental Science & Policy* 54 (December): 475–81. https://doi.org/10.1016/j.envsci.2015.05.008.

Rhoades, Robert E., ed. 2006. *Development with Identity: Community, Culture and Sustainability in the Andes*. Wallingford, UK ; Cambridge, MA: CABI Publishing.

Rocheleau, Dianne E., Barbara P. Thomas-Slayter, and Esther Wangari, eds. 1996. *Feminist Political Ecology: Global Issues and Local Experiences*. International Studies of Women and Place. London ; New York: Routledge.

Rodríguez-Mahecha, José V., Paul Salamen, Peter Jorgensen, Trisha Consiglio, Luis Suárez, Fabio Arjona, and Robert Bensted-Smith. 2004. "Tumbes-Chocó-Magdalena." In *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*, edited by Russell A. Mittermeier, 1st ed., 73–79. Mexico City: CEMEX.

Roitman, Karem. 2008. *Hybridity, Mestizaje, and Montubios in Ecuador*. English. QEH Working Paper Series 165; ODID Working Papers 165 University. Oxford: University of Oxford, Dep. of International Development. http://www3.qeh.ox.ac.uk/pdf/qehwp/qehwps165.pdf.

Rose, Gillian. 1997. "Situating Knowledges: Positionality, Reflexivities and Other Tactics." *Progress in Human Geography* 21 (3): 305–20. https://doi.org/10.1191/030913297673302122.

Safarzynska, Karolina. 2013. "The Coevolution of Culture and Environment." *Journal of Theoretical Biology* 322 (April): 46–57. https://doi.org/10.1016/j.jtbi.2013.01.004.

Santacruz, Harold Moncayo. 2009. "Origen de Los Pueblos Pastos. Resumen de Investigación." En Rupestreweb. 2009. http://www.rupestreweb.info/pastos.html.

Scharmer, Claus Otto. 2009. *Theory U: Leading from the Future as It Emerges*. San Francisco, Calif: Berrett-Koehler.

Schilthuizen, Menno, Lilian Seip, Sean Otani, Jadda Suhaimi, and Iva Njunjić. 2017. "Three New Minute Leaf Litter Beetles Discovered by Citizen Scientists in Maliau Basin, Malaysian Borneo (Coleoptera: Leiodidae, Chrysomelidae)." *Biodiversity Data Journal* 5 (June): e21947. https://doi.org/10.3897/BDJ.5.e21947.

Schlager, Edella. 2007. "A Comparison of Frameworks, Theories, and Models of Policy Processes." In *Theories of the Policy Process*. Boulder, CO: Westview Press.

Shirk, Jennifer L., Heidi L. Ballard, Candie C. Wilderman, Tina Phillips, Andrea Wiggins, Rebecca Jordan, Ellen McCallie, et al. 2012. "Public Participation in Scientific Research: A Framework for Deliberate Design." *Ecology and Society* 17 (2). https://doi.org/10.5751/ES-04705-170229.

Silva, Philip. 2016. "Epistemic Cultures in Civic Ecology Practices: Making New Knowledge through Stewardship." presented at the Citizen Science Symposium, Philadelphia, PA. https://www.youtube.com/watch?v=3ZnwZUkRvBY&t=1091s.

Simons, Gary F., and Charles D. Fennig, eds. 2017. "Ecuador." In *Ethnologue: Languages of the World*, 20th ed., https://www.ethnologue.com/country/EC. Dallas, Texas: SIL International.

Song, Chorong, Harumi Ikei, and Yoshifumi Miyazaki. 2016. "Physiological Effects of Nature Therapy: A Review of the Research in Japan." *International Journal of Environmental Research and Public Health* 13 (8): 781. https://doi.org/10.3390/ijerph13080781.

Spiegel, Jerry M, Jaime Breilh, Efrain Beltran, Jorge Parra, Fernanda Solis, Annalee Yassi, Alejandro Rojas, et al. 2011. "Establishing a Community of Practice of Researchers, Practitioners, Policy-Makers and Communities to Sustainably Manage Environmental Health Risks in Ecuador." *BMC International Health and Human Rights* 11 (Suppl 2): S5. https://doi.org/10.1186/1472-698X-11-S2-S5.

Steffen, W., K. Richardson, J. Rockström, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, et al. 2015. "Planetary Boundaries: Guiding Human Development on a Changing Planet." *Science* 347 (6223): 1259855–1259855. https://doi.org/10.1126/science.1259855.

Stone, Jonathan, Jenni Barclay, Peter Simmons, Paul D Cole, Susan C Loughlin, Patricio Ramón, and Patricia Mothes. 2014. "Risk Reduction through Community-Based Monitoring: The Vigías of Tungurahua, Ecuador." *Journal of Applied Volcanology* 3 (1). https://doi.org/10.1186/s13617-014-0011-9.

Suarez, Luis. 1988. "Seasonal Distribution and Food Habits of Spectacled Bears *Tremarctos Ornatus* in the Highlands of Ecuador." *Studies on Neotropical Fauna and Environment* 23 (3): 133–36. https://doi.org/10.1080/01650528809360755.

Toomey, A. H. 2011. "Empowerment and Disempowerment in Community Development Practice: Eight Roles Practitioners Play." *Community Development Journal* 46 (2): 181–95. https://doi.org/10.1093/cdj/bsp060.

Torre, Carlos de la, and Steve Striffler, eds. 2008. *The Ecuador Reader: History, Culture, Politics*. The Latin America Readers. Durham: Duke University Press.

Toth, Gergely, and Cecília Szigeti. 2016. "The Historical Ecological Footprint: From over-Population to over-Consumption." *Ecological Indicators* 60 (January): 283–91. https://doi.org/10.1016/j.ecolind.2015.06.040.

Townsend, Wendy R., A. Randall Borman, Eduardo Yiyoguaje, and Luis Mendua. 2005. "Cofán Indians' Monitoring of Freshwater Turtles in Zábalo, Ecuador." *Biodiversity and Conservation* 14 (11): 2743–55. https://doi.org/10.1007/s10531-005-8410-1.

Ulrich, Roger S., Robert F. Simons, Barbara D. Losito, Evelyn Fiorito, Mark A. Miles, and Michael Zelson. 1991. "Stress Recovery during Exposure to Natural and Urban Environments." *Journal of Environmental Psychology* 11 (3): 201–30. https://doi.org/10.1016/S0272-4944(05)80184-7.

Velez–Liendo, Ximena, Frank Adriaensen, and Erik Matthysen. 2014. "Landscape Assessment of Habitat Suitability and Connectivity for Andean bears in the Bolivian Tropical Andes." *Ursus* 25 (2): 172–87. https://doi.org/10.2192/URSUS-D-14-00012.1.

Viviroli, Daniel, Hans H. Dürr, Bruno Messerli, Michel Meybeck, and Rolf Weingartner. 2007. "Mountains of the World, Water Towers for Humanity: Typology, Mapping, and Global Significance: MOUNTAINS AS WATER TOWERS FOR HUMANITY." *Water Resources Research* 43 (7): n/a-n/a. https://doi.org/10.1029/2006WR005653.

Vuille, Mathias, Raymond S. Bradley, Martin Werner, and Frank Keimig. 2003. "20th Century Climate Change in the Tropical Andes: Observations and Model Results." In *Climate Variability and Change in High Elevation Regions: Past, Present & Future*, edited by Henry F. Diaz, 15:75–99. Dordrecht: Springer Netherlands. http://www.springerlink.com/index/10.1007/978-94-015-1252-7_5.

Vuille, Mathias, Bernard Francou, Patrick Wagnon, Irmgard Juen, Georg Kaser, Bryan G. Mark, and Raymond S. Bradley. 2008. "Climate Change and Tropical Andean Glaciers: Past, Present and Future." *Earth-Science Reviews* 89 (3–4): 79–96. https://doi.org/10.1016/j.earscirev.2008.04.002.

Wiggins, Andrea, and Kevin Crowston. 2011. "From Conservation to Crowdsourcing: A Typology of Citizen Science." In , 1–10. IEEE. https://doi.org/10.1109/HICSS.2011.207.

Wiggins, Andrea, Greg Newman, Robert D. Stevenson, and Kevin Crowston. 2011. "Mechanisms for Data Quality and Validation in Citizen Science." In , 14–19. IEEE. https://doi.org/10.1109/eScienceW.2011.27.