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Montology manifesto: echoes towards a transdisciplinary science of mountains

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Abstract: Mountains as archetype frame some meta-geographies of the vertical dimension. Mountain metaphors, thus, have remained as key guidance in developing not only animistic belief systems and religious cults, but also military strategies, economic potential, and scientific innovation. This paper seeks to explain the need to integrate western knowledge, where mountains became known via natural history's mechanistic explanations, with other epistemologies. Mountain scientists therein developed linear approaches that required exploration, experimentation, and pragmatic interpretation of generalizable mountain phenomena. Little is known, however, about other civilizations' more encompassing cognition due to heuristic explanations of mountain myths. Local knowledge holders therein developed approaches that required familiarization, observation, and romantic meditation about situated mountain phenomena. Using a multimethod approach of human geography that includes onomastics, geocritical discourse analysis, political ecology, and critical biogeography, the author posits that there is a paradigmatic shift of geographic fad, when even "nature" is thought of as a "social construct" in the socioecological mountainscapes. Between these tendencies of either Cartesian or Spinozan dogmas about scientific objectives, methods and implications, mountains continue to elicit geographical research. The author thus concludes that integrating narratives of mountain studies with geocritical analyses of political ecology that allow for transgressivity and referentialilty of mountain cognition can be done with transdisciplinary science. Montology, henceforth, couples dialectic thinking with the trifecta of spatiality, complexity and historicity in highlighting mountain microrefugia for biocultural conservation. Use of montological approaches will bring mountain scientists to a new level, where the application of local ecological knowledge and cutting-edge technological instrumentation could render sustainable mountain communities, in dynamic biocultural heritage scenarios of convergent mountain science.

Keywords: Montology; Geocriticism; Biocultural Heritage; Transdisciplinarity; Mountain cognition; Mountainscape.

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Introduction

Montology, as the transdisciplinary science of mountains, is informed by several disciplines, like critical geography, ethnogeomorphology, regional studies, and political ecology, while aiming to implement science-based solutions for sustainable and regenerative mountain development. The very essence of these studies makes it difficult to define "mountain" as the futile effort that was being likened to chasing a chimera (Messerli and Ives 1997); likewise it can be said to define "montology"; not only for the different methods and techniques applied to understand altitudinal limits, but also for the integration of different epistemologies and environmental cognition approaches from different cultures (Sarmiento 2020). A growing chorus of voices from mountain scholars has been calling for this novel view of the discipline for a number of decades (Mahat and Boom 2008). The argument

relies on the perceived need of a comprehensive understanding of mountainscapes from a professionalized identity that includes montologists working from disparate topics for the creation of the modern ontology of mountains (Sunyer 2020) and their inclusive identities of mountain communities. Mountainscapes are the appropriated and represented reality of three factors: 1) the physical mountain edifice, 2) the psychological appropriation of mountainous socio-ecological systems, and 3) the spiritual and mythical alignments of mountain folk in one cogent identity.

A unified, holistic framing opens new and exciting avenues for understanding human-environmental relations (Koutsopoulos 2011) that are particularly poignant in grappling with the dynamics of mountains socio-ecological systems (Boillat 2020); holistic insights have expanded intellectual frontiers of mountain geography, particularly in the Global South (Young 2020). Recently, the search for integrative approaches to understand Complex Adaptive Systems (CAS) (Holland 1992; Nelson et al. 2020) and the long-term stewardship of mountain ecosystems as Socio-Ecological Systems (SES) (Ostrom 2009; Lejano 2019) have led to a renewed focus in "Montology" (Haslett 1998; Sarmiento et al. 2017: Borsdorf and Haller 2020).

These evolving theoretical and practical applications, combined with urgent contemporary concerns like climate change, regenerative development and sustainability, call for a critical reappraisal of mountain geography (Chignell and Laituri 2016). A fresh look at the discipline is clearly more than warranted. This mountain manifesto is an effort to clarify the way we study mountains and to use foreign lexicographic terms, as montology, into clearly understandable English terms to expand comprehension of unorthodox geographic traditions or conventionalisms that are devalued in the Global North, but are of uttermost importance in the less developed mountain nations, or in original peoples' mountain communities of the Global South. In the process, I hope to redefine our sense of place and to grapple with hidebound, hoary conventions of mountain studies. In so doing, I will demonstrate how the transdisciplinary view of montology fundamentally changes our way of thinking about geographic realism, socio-ecological systems (SES) and the "nature" of mountainscapes.

An increasing availability of information, greater funding, and academic training mean that modern mountain scholars face a complex and contradictory labyrinth of environmental cognition -- much of which is guided by reductionist principles, theoretical dogmas and outdated technologies (Gustafson 1998; Price 2015). These scholars found themselves locked in binary silos that branded them as either "physical geographers" or "human geographers". However, with the realization by ecologists and other social scientists that geography is the environmental science *par excellence* (Wulf 2015a), more and more professional geographers have internalized the notion that navigating the complex adaptive system (CAS) of mountains must be done along the spectrum. Integrative, comprehensive, and critical views of mountainscapes (Wilcock and Brierley 2012) require viewing them as dynamic systems functioning in the present (Massey 1999) rather than peering through the lens of the static, descriptive views of mountain geography's past (Wulf 2015b).

1 Conceptualization

The research design assumes a general agreement of what a mountain is, despite different acceptance and attempts to define it (Gerrard 2014; Chakraborty 2020; Pitches 2020), as well as recognizing that mountains refer only to the topographic features above ground, due to the vast underwater marine mountain chains and islands are seldom included in mountain literatures. Hence, the study area circumscribes the known continental highland terrain and aggregates different epistemologies and investigative emphases provided by diverse mountain geographies and ecologies. In several cases, I use examples from the Neotropical mountains to reflect my own expertise. I use the geographic tools of historicity and spaciality to analyze the "essence" of mountains, utilizing critical discourse analysis, bibliometrics and data-mining, onomastics and geocriticism, to inform the state of the art of mountain studies.

1.1 Historicity of the dawn of montology

"Montology", a term coined by mountain

geographers Jack D. Ives in Canada and Bruno Messerli in Switzerland, requires transdisciplinary study if our understanding about SES and CAS is to truly reach its fullest potential (Mainali and Sicroff 2016). "Inter-disciplinary" and "Multi-disciplinary" approaches of the past have only resulted in a fragmentation of opinion and study. The crosscutting theme of mountains, thus, requires a "Trans-disciplinary" framework.

One of the first accounts (Mahat and Bloom 2008) states, "The term montology has been used in oral communication, and in print many times over the past twenty-five years. According to Jack Ives, Frank Davidson informally introduced the term in 1974, in Munich, Germany, at the same conference in which the journal *Mountain Research and Development* (MRD) and a future International Centre for Integrated Mountain Development (ICIMOD) were envisioned. The Munich conference proceedings reported: "just as oceanography has spawned a number of major and minor institutions concerned with the protection and development of ocean resources, so mountainology, once its importance and implications are realized, will lead to a proliferation of institutional responses" (GTZ 1974). In subsequent discussion between Frank Davidson and Jack Ives, the term mountainology was dropped in favor of montology".

When the call went out to change "mountainology" to "montology" in 1974, the first hurdle was lexicographic, i.e., convincing the world that the name of the science had changed. The so-called "Club of Munich" (a group of scholars that organized the experts' workshop on mountains in Munich) persisted in the effort of highlighting mountain research, which became stronger with the addition of American scholars such as Paul Baker, Ben Orlove, Steve Brush and Colin Rosser, and the consolidation of the International Mountain Society (IMS) and its journal *Mountain Research and Development* (MRD) (Ives 2005). The International Geographical Union (IGU) via its Commission of Mountains also supported this trend, first with Troll's geocology trend and later with Ives' montology eminence. Soon after, this momentum fared prominently in the Cambridge Mountain Conference of 1977, demonstrating a widespread need for transdisciplinary approaches in the field. The proceedings from that conference say, "At the Cambridge Mountain Conference in 1977, participants discussed the creation of a discipline for the study of mountains, as has been accorded to oceans, and gave it the name of montology, to denote an active, protective emphasis."

The first paper printed on montology soon followed (Neudstadtl 1977). However, its global attention was launched with the publication of the book "Mountains of the World: A Global Priority" (Messerli and Ives 1997): in its final chapter (pp 460-466), coauthored by both of them and Robert Rhoades, they gave a coda with a specific call to make montology the science of mountain studies. This book was widely distributed as preparations for the celebration of the International Year of Mountains (IYM) held in 2002 and launching a coordinated effort of "the Mountain Maffia" to move the Mountain Agenda into the world stage. This edition has been translated into many languages and updated to emphasize regional priorities (e.g., Badenkov 2002; Sarmiento 2003). The term montology was included in the unabridged Oxford English Dictionary in 2002, generating debate between those that saw it as jargon or unnecessary, and those that claimed disciplinary identity with the exclusive moniker.

Many researchers from the Global South became advocates of the term, as shown in many articles of the *Journal of Mountain Science* (JMS) published by the Chinese Academy of Sciences and Springer and in several exchanges and newsletters of the Mountain Forum (MF). In addition, because of the multidisciplinary nature of mountain ecosystem studies, many articles of Pirineos, the *Journal of Mountain Ecology*, published by the Spanish Council of Science and Technology, have covered the gamut of topics for montology.

1.2 Transdisciplinary imperative for mountains

Noting a sort of global ambivalence toward transdisciplinary thinking in the mountain scientific community, a call to "move up Mountains" in the global environmental agenda was formalized (Bandyopadhyay and Perveen 2004), which prompted the call for more discussion on whether mountain scholars and practitioners needed a cross-cutting field of their own, meaning

montology (Rhoades 2007).

In the development of the scientific narrative of the novel cross-cutting approach, the application of transdisciplinary science started (Piaget 1972) and became standard in modern academia (Nicolescu 2002; Hadorn et al. 2008); with increased popularity, this approach implied mainly three substantive gains: a) holistic health science and medicinal issues (Klein 2008), b) the bridging of traditional or antiquated academic disciplines (Veteto 2009) , and c) the need for integration of novel fields (Nanshan 1998). Those works did not mention mountains specifically, but paved the way to understand better what is the present mountainscape.

Not only the recognition of mountainscapes as CAS, but also the realization that those mountainous landscapes were actually SES, propelled scholarship towards seeking explanatory research for emergent properties of mountain sustainability (Polk 2014) and the transformation leading to it (Klein et al. 2019). The partnership of multi-method research (Aliyu et al 2014) became montologists's favorite toolbox because it included approaches to understand complex, adaptive systems, i.e., their diversity, memory, openness, synergy, uncertainty and resilience, particularly amidst global environmental transformation, including climate change research (Ding and Zheng 1996) and regenerative development (Muller 2020) for sustainability.

Nevertheless, because of the hegemony of scientific production in western ecological knowledge (WEK) of sophisticated research centers, the term "Mountain Studies" has been popularized to indicate interdisciplinary attempts to understand mountains. However, voices of the Southern Hemisphere claim the recognition of their own epistemologies of mountains, insisting on the need for the field to be transdisciplinary. To their view, the study of mountains is incomplete if it fails to incorporate traditional ecological knowledge (TEK) and alternatives from ancestral wisdom of Indigenous Ecological Knowledge (IEK). In many cases, ancient, indigenous knowledge trumps Western and other modern ontologies for mountainscapes when dealing with landscape memory, sacred dimension or identity traits of mountain people (Sarmiento & Hitchner 2017).

1.3 Breaking disciplinary boundaries

At the onset of the new century, the need to better define Mountain Geography had become critical. Several attempts to develop a comprehensive textbook for mountains existed whether be in alpine geography, ecology, geomorphology or forestry. Recent results of integrative studies (Price et al. 2013) laid bare the importance of the intersection of the physical environment with the human dimensions (Lave et al. 2014; Sarmiento 2015). Highly respected mountain scholars have also incorporated Ives and Messerli's montological vision, including Axel Borsdorf, Christoph Stadel, Yuri Badenkov, Robert Rhoades, Larry Hamilton and many more (Ives et al. 2016).

To grapple with the trope of disciplinary boundaries, I use the geo/eco driven onomastics of "mountain specificities" (Jodha 2003) to describe the transgression of traditional geocriticism's tenets (Westphal 2011; Tally and Battista 2016). The possible "bridging" of the science and the humanities made viable with the methodology of Geocriticism allows for the use of onomastics as a methodological stratagem, as part of the critical discourse analysis method. Some problems arise in the use of foreign words that lack direct English translation, however. In a review of critical physical geography (see Figure 1) of the three literacy dimensions, researchers needed to truly contest the naming of the discipline by retooling their thinking about mountains (Tadaki 2017) by being:

1) critical-in or *geoliterate*, in the physical biogeographic mountain setting, encompassing descriptive, meristic variables;

2) critical-of or *ecoliterate*, in the socio-ecological mountain production system, including analytical, non-meristic variables; and,

3) critical-through or *sopholiterate*, in the mental mountain imaginaries, encircling mythological, ethical and moral variables.

At this juncture, this new epistemology seeks to radicalize geoscience (Castree 2015) but contains linguistic artifacts, which convey ideas of physical, mental and spiritual dimensions, without a readily translatable English term. The push toward acceptance of montology as a foreign word is perhaps hampered by its non-English origins. Furthermore, the word appears to straddle the

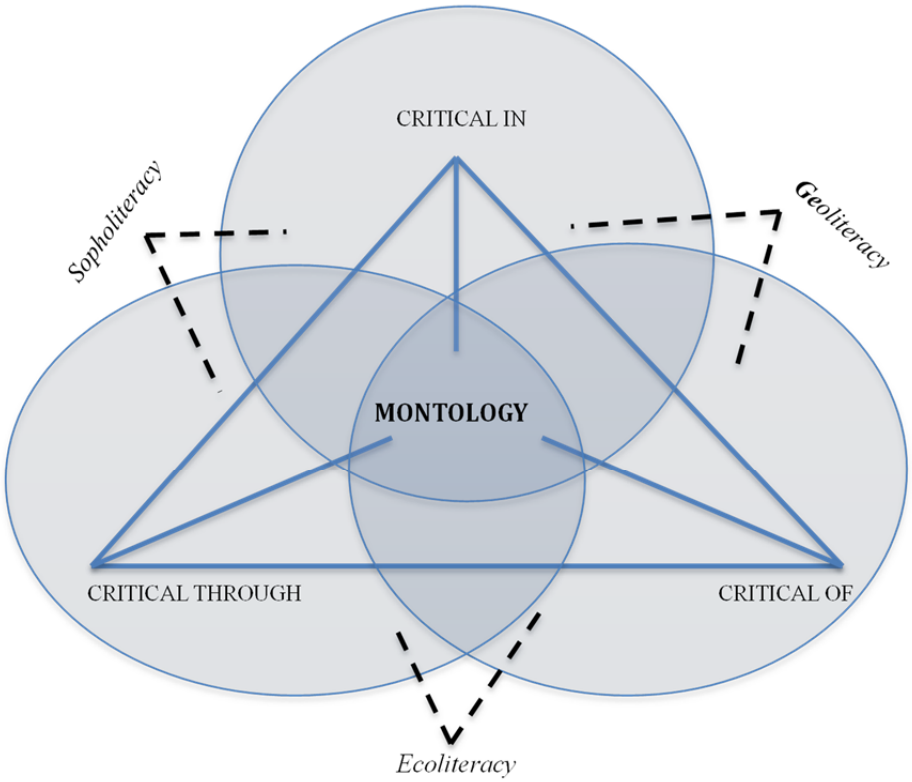

Figure 1 The interaction of the spheres of transgressivity to allow for critical geography of mountains to operate in a Gestalt system aimed to last for a long time, by connecting the descriptive physical variables with both the analytic behavioral variables or the mental imaginaries of mountain communities. The lack of arrows in connecting lines represents the non-hierarchical and non-directional nature of the interactions of the trialectic spectral process instead of the past binary directional dialectic one.

confines of science and humanities, which can meet resistance from some whose roots are in so-called "hard sciences" instead of the "soft sciences." This glitch forces the reader to use whole sentences (instead of simple terms used to distinguish between disparate concepts within cognate subjects) to speak with transgress about mountain cognition (Prieto 2011). Otherwise stated, I used inverse definition approach methods to make them clearer by defining what they are not, instead of what they are. As examples of languages with such untranslatable terms I include Arabic (*barzakh*), Portuguese (*saudade*), Sanskrit (*karma*), Spanish (*arraigo*), French (*terroir*), and German (*Gemütlichkeit*). I invite English-oriented readers to stretch their minds to include blocks of unfamiliar terms below.

As geocriticism becomes the methodological tool of choice for understanding environmental literature (Prieto 2016), I blurred boundaries of mountain themes between science and humanities, making geoliteracy far more relevant than ecoliteracy in mountainscapes. Ecoliterate thinking largely points to a "nature only" form of shrewdness of the biological landscape. I considered geoliteracy linkages between nature and culture, indicating that what we discover in the mind will be much richer than those obtained by more traditional thinking of the body (Convery & Davis 2016).

Even the once-rigid boundaries between science and art are becoming more permeable. In STEM disciplines -- c.f., science, technology, engineering, mathematics -- a growing cadre of educators are changing the acronym to STEAM, to include the arts. Hence, mountains are now not only validated by technological applications of pure science or engineered solutions and algorithms, but are also substantiated by artistic production and humanistic artifacts, such as religion, history, literature, etc.

1.4 Trends of unifying and funding a mountain discourse

The lexicographic controversy even extends to specialized bibliographies on mountain geography (Resler and Sarmiento 2016), integrating holistic premises and postmodern and poststructuralist thought-provoking methods of mountain research as part of listing bibliometric and analytical sourcing with this new trend of multifunctional approaches for mountain CASs and SESs (Sarmiento et al. 2017).

Therefore, an in-depth understanding of "Mountain Research" requires a shift back-and-forth from the archaic term *orology* (a Greek-based term for mountain and knowledge) to the postmodern term *montology* (derived from mixed Latin and Greek etymology for mountain discourse). The lexicographic shift potentially demonstrates a trend to incorporate more-than-human elements and spiritual dimensions in the modern understandings of mountainscapes as SESs and CASs. Critics of the term disparaged this etymological mixing, without realizing that many scientific disciplines already mix Latin and Greek roots, including mineralogy, inscriptology, phraseology, oceanology, etc. (Yuanchang 1986).

New convergent research includes not only multidisciplinary concepts or interdisciplinary concepts (*sensu lato*), but also transdisciplinary teams (*sensu stricto*) that allow a collective of researchers and practitioners to understand a diversity of issues (Nicolescu 2002; Klein et al. 2019), from farmscape transformation for agrobiodiversity (Zimmerer et al. 2016) to the risk of glacier retreat and climate change adaptation for resiliency and risk assessment (Carey 2010). It is through the appreciation of many literary texts and disciplines, and their diffusion through the world's cultures, that montology is finding its grip on the human imagination (Tally and Battista 2016).

As of late, funding agencies have prioritized transdisciplinary teams for successful proposals, in many cases affirming the need to fuse "hard science" with some social science, requiring multidisciplinary teams to integrate also ground-truthing and local expertise, or directly create consortia of institutions or programs to deal with mountain regenerative development for sustainability (Klein et al. 2019). An example is the creation of groups that take such an approach in American universities with National Science Foundation (NSF) funding: TARN (Transdisciplinary Andean Research Network) funded by NSF as a Collaborative Research Network (Polk et al. 2017) or the SENTINELS group for mountain observatories (https://mountainsentinels.org/), MtnSEON (Mountain Social Ecological Observatory **N**etwork (https://webpages.uidaho.edu/mtnseon/) and the NMC (Neotropical Montology Collaboratory (http://research.franklin.uga.edu/Montology/).

Another international example is the project VULPES (Vulnerability of Populations Under Extreme Scenarios) funded by the *Belmont Forum* (https://www.belmontforum.org) for global research on mountains and climate change applications, dealing with microrefugia conservation research of mountain forests' paleodynamics and current ecological trends in several selected sites around the world (https://vulpesproject.wixsite.com/vulpes) (Cheddadi et al. 2017; Cheddadi et al. 2019).

Further indication of this vogue in favor of montology is the policy implemented by the former German International Cooperation for Development institute (GTZ 2013) to only fund development projects if they observe transdisciplinary tenets. Academically, the effort is invigorated by the United Nations University's Institute of Advanced Studies in Sustainability (UNU-IAS), and the Institute for Global Environmental Sustainability (UNU-IGES) out of UNU's headquarters in Japan, a successful International Program of the Satoyama Initiative (IPSI) of socio ecological production landscapes and seascapes (SEPLS) (http://satoyama-initiative.org/partnership/). Another important contribution comes from Sustainability Science researchers who have identified the transdisciplinary basis of montology (Lang et al. 2012). In the City of Science, near Tokyo, a UNESCO chair on Nature-Culture Linkages keeps many scholars at the Mountain Research Center of the University of Tsukuba busy researching biocultural heritage (http://nc.heritage.tsukuba.ac.jp/UNESCO-Chair/) within the tenants of montology for the Master's degree in Mountain Science. An example from Europe brings the efforts of the Austrian Academy of Sciences (OeAW)

in the establishment of an innovative Institute for Interdisciplinary Mountain Research (IGF) (https://www.oeaw.ac.at/en/igf/) that publishes a new mountain journal, *EcoMont*, for socioecological systems and protected areas. An example from South America is the Research Institute for Sustainable Development of the Cloud Forest (INDES_CES) (http://indes-ces.edu.pe/web/) of the National University Toribio Rodríguez de Mendoza in Amazonas that fuses agroecological applications with environmental health in the Andean Amazonian flank.

A key move in favor of montology came from MRD (*Mountain Research and Development*), that assumed an editorial policy with guidelines to incorporate articles dealing with mountain knowledge generation, application and sharing, with clear reference for inclusion of traditional ecological knowledge (TEK), soft and hard science. The goal was to understand the North-South global dynamics of regional mountain sustainable development. Coincidentally, MRD was founded and edited by Jack D. Ives and published by the International Mountain Society (IMS) until 2000, when the new open journal became available online, funded mainly by the Swiss Development Corporation and edited by Hans Hurni at the Institute of Geography of the University of Bern. At present, Thomas Breu (U Bern) and David Molden (ICIMOD) are editors-in-chief, working with associated editors Anne Zimmermann, Susanne Wyman von Dach and Sarah-Lan Mathez-Stiefel, at the Center for Development and Environment of the University of Bern.

1.5 Mountains as methodological research subjects

With the advent of critical social theory and postmodernism, scientific disciplines that followed strict frameworks of quantitative, descriptive, dialectic phenomena in the hypothesis-testing procedures, have found the need of incorporating qualitative, analytic phenomena of trialectics. This requires a different mindset, as well as different tools and protocols, such as onomastics and term causation or etiology, political ecology explanatory tropes and critical biocultural heritage paradigms (Sarmiento 2016a). The fruitful discussion about mountains as research subjects and their methodologies have been explored elsewhere (Debarbieux 1999; Sarmiento 2001; Funnell and Price 2003; Perlik 2019).

Thus, in order to understand mountain theory from either side of the scientific divide, whether following Cartesian determinism or Spinozan relativism, the need of a transdisciplinary field for mountain studies is self-evident for sustainability paradigms (Painter 2008; Hansson 2012). Following the "cartographic anxiety" (Gregory 1994) of mountains, created by linkages of nature/culture defiant of truism, it urges the epistemology of geoliteracy (*critical- in),* ecoliteracy (- *of)* and sopholiteracy (- *through)*. Thus, montology becomes a *tour-de-force* of current thinking of mountain research, particularly in the Global South, where the majority of humanity practice non-Western thought (Sarmiento and Frolich, 2020).

To reify the mountain epistemes, I use the Arabic term *al-barzakh* that describes a condition for the Islamic afterlife, what Catholics interpret as "purgatory" in Western thinking. However, it goes much further in describing the fuzzy line that separates two adjacent realities that are often hard to separate. For instance, the line that separates life from death, light from darkness, or the line that separates the present from the past, or even the separation of the seen and the imagined, some even suggest that separates what constitutes the realm of humans and of gods. This is precisely what montology does in helping to understand the trifecta of mountain ecosystems, by helping to form a complete picture of the mountainscape.

Using the example of the Andes, the epistemology of mountains can be either deducted from what it seems and it can be touched and measured (in terms of its "Andeanity"), or can be inducted from what it appears to be and it can be conceived and planned (or "Andeaness"), or can be subducted from what it means and it can be revealed and imagined (or "Andeanitude"). The Sarmiento's trilemma has now been applied to explain Andean identity and the force that moves effective mountain conservation (Sarmiento 2016b) based on the reciprocity concept of the Andean lifescape (or *Ayni*) that lays in the interstitial space of this *al-barzakh*. Therefore, the Sarmiento's trilemma for Andean identity can be applied to find the "essence of place" in other mountain systems as well, by incorporating the so-called deep ecology

consideration of landscape dynamics, to complement the simplistic landscape metrics to describe measurable attributes (Ritters 2019). You may think of Alpeaness, Appalachianity, or Himalitude when you are searching in the people of mountains for the hidden mental framework of the Alps, the physical spatialities of the Appalachians or the sacred and spiritual markers of the Himalayas (See Figure 2).

2 The Longing for Geocritical Montology

At present, in major urban centers, the economic and social meaning of mountain livelihood is diminished, often due to man-made facilities and infrastructure (Borsdorf and Haller 2020). The highways and public utilities that allow for easy connectivity and short travel time, the flat terrain, shipping harbors, and central locations for urban businesses that form cityscapes' economic backbones are mostly associated with the lowlands and deltas (Messerli and Ives 1999). In the past, mountain civilizations typically developed their core areas in isolated, often forgotten valleys, where they remained isolated to the edges of society, relegated to marginal spaces where they evolved in unique groups as well as social and hegemonic hierarchies. This ridge-and-valley geographical isolation produced a subspeciation of groups with different cultures, languages, creeds and available resource uses (Lewis and Wigen 199; Zimmerer et al. 2017) particularly imprinted in mountain people's minds, defining their livelihoods.

It is here that the Portuguese term *saudade* comes into place, as something that is longed for without proper realization. Most citizens, including the suburbanites and exurbanites of amenity areas worldwide have shown a trend to incorporate aspects of 'mountain specificity' to survive in the faraway port cities or urban sprawls of the lowland cityscape. This longing for the mountain is evident in the manifestation of second-home development in the peri-rural, rurban, and peri-urban fringes or in summer home retreats of the expatriates (c.f., amenity migrants) around the world, particularly in the tropical mountains (Moss 2006).

However, in spite of this nearly atavistic human yearning for mountain symbols and reminders, the people who live among the mountains are identified as "the Other". As the old Irish saying goes: "You can take the boy out of the mountains, but you can never take the mountains out of the boy." Thus, montology allows putting personalized perspectives in the deeply ingrained notion of mountain lifescapes, often politicized and appropriated by contested political ecologies of distant urban cores (Debarbieux 2008).

In the current globalization race, mountains provide the much needed brake not only to the monotonous flat topography, but they also enhance quality of life by providing valuable ecosystem services (ES) such as drinking water, clean air, ample vistas, alternative resource potential, wildlife refuge, spiritual fulfillment, theophanies and epiphanies, sanctuaries for ancient practices, national pride, historical memory, tourism and recreation, and more intangibles worth protecting as biocultural heritage for the mountains' sustainable future (Termorshuizen and Opdam 2009). Cultural ecosystem services (CES) of mountains are now been highly regarded as important parameters to size the plans for future mountain conservation–with-development programs and institutions (Schirpke et al. 2016).

2.1 The transgressivity of mountain lore

With the first book on Geocriticism, appeared in French in 2007 and its English translation (Westphal 2011), the term transgressivity took hold in many social science writings, including mountain themes. The willingness to transgress, to defy traditions, break borders, debunk stereotypes and open frontiers to mesh the sciences and the humanities became not an opium fantasy, but a blueprint for future thought, evenly among physical and social sciences. On the other hand, the transgression sea-change is known for its complex urban-rural edges (Soja 1996; Colpaert 2018) and particularly on the integration of multimethods research to inform the challenge of framing the continually shifting mosaics of rurban mountain environments (Zimmerer 1994) for securing foodscapes.

However, in order to effectively integrate mountain knowledge, so-called Gestalt systems must come into play (Wertheimer 2017). Gestalt by definition is a physical,

biological, or symbolic configuration or pattern of elements so unified as a whole that its properties could not be identified from a simple summation of its parts (Smith 1988). In Gestaltism, there are different factors that have to work together to create order out of chaos, among them: Emergence of the whole before the parts; Reification of objects with imaginary to fill the gaps; Multi-stability by having alternative pathways seeking to avoid uncertainty; and Invariance by locking patterns to fast recognition (Naveh et al. 2002). All those conditions apply when dealing with mountain communities as CASs.

Montology allows the integration of scientific methods and traditional wisdom to follow the Gestalt principles of spatial arrangement (Bradley 2014); including the laws of simplicity, of closure, of symmetry oriented to a central place, of figure/ground contrasting elements, of uniformity and connectedness, montology conforms with providing a unified wholistic view of the mountainscape. Additionally, Gestaltism forms the tenets of common regions, including proximity, continuation, synchrony or common fate, parallelism and similarity; focal points or locus; and past experiences, which is key to understand mountain landscape memory (Macfarlane 2009). Separating its constitutive elements, one would never acquire a holistic perspective of mountains for the lack of integration and summation.

Hinduism and Buddhism aver that the cumulative actions of the Self propel the individual towards higher and more complex levels of integration. The *Karmic* drive towards improvement of soul and body calls for a transcendence of the Self and its outmoded methods of understanding. Similarly, montology pushes mountainscapes toward higher organization and complexity. An important account of a lifetime effort is given on the Himalayan experience (Ives 2013).

2.2 The referentiality of mountainous environments

In the recognition that mountains -- by definition -- are atypical geoecological spaces, it follows that anthropogenic landscapes are what we could consider palimpsests, offering surprises and anomalies of all kinds in manufacturing each of the consecutive editions of the mountain past in writing the present mountainscape. Many mountains are fitted with bioengineered modification by ancient practices that may/may not be readily visible. In fact, UNESCO considers them "intangible" heritage, and most scholars have included the term "manufactured landscapes" to indicate the intricate effect of human impact on natural vegetation and treelines of mountains, translated to the present by ecological legacies of the landscape. Now we know that the idea we have about mountains is largely informed by history and political expedience, which becomes clear in the confusion of biologists and ecologists when tabulating diversity of Neotropical forests, that "look" pristine (realized mountainscape), but in reality, are hidden SESs and CASs (fundamental mountainscape) (Myster 2020).

These interventions have since millennia constructed anthromes that are deeply respected and cared for by the mountain folk (Scheiber and Zedeño 2015). An example from the Andes brings the Spanish term *arraigo* as reference for the love of the land, not only on the territoriality of their construction, but also in the imaginary and representation of ancestry, identity, even nationality. The people of the highlands exhibit a highlighted trait of deep *arraigo* typical of Andean portraits (Borsdorf and Stadel 2016).

However, the term is more than just the rootedness of a person in the area of residence; they are intrinsically linked to the essence of land in space and time. This linkage requires recognition of the social belonging to a place made by intimate relationships with the various elements of the mountainscape. In *Kichwa* language *or runashimipi,* the word *pachamama* describes not only the land and its products, but also the tenderness of rearing as part of the communal effort, where reciprocity or *ayni* is manifested as the engine of social cohesion of different mountain groups or *ayllu*, and gratitude is acknowledged with payments and offerings or *"pagamentos"* to the land linked in space, with the three commandments for *Inka* wellbeing or *sumak kawsay*, when they are balanced within the trilemma: Do not steal (*ama sua*), do not lie (*ama killa*) and do not be lazy (*ama llulla*) (See Figure 2).

They are also intimately linked to the landscape in time, as they train the young in the

labor of the land, but also respect the old by providing them a hierarchical place of power with elders often running decision-making. The links in time go back to several generations, as it is common for them to bury the dead underneath the floors inside their houses, mimicking the ancestral practice of mummifying the dead. Having this intimate relationship with the land makes "*arraigo*" one of the most cherished values (Sarmiento 2012). Conversely, one of the worse punishments in the Andes is to take the person away from his/her homeland. Extirpated prisoners of war or *mitima* were often forced to colonize faraway lands during the *Inka* territorial expansion. Even at present, Andean communities' first and foremost political platform is land and house or *wasi* ownership, communal territories or *llakta* titling, and water rights associated with their cherished homeland or *manta* respect.

2.3 Human impacts on mountain environmental services

Montology is proposed as the transdisciplinary venue to understand mountain science, as it was first observed in 1802 by the father of ecology, who is also considered the father of geography, and the father of climate change. Humboldt used pragmatism and positivist research along with qualitative idealization of the territory in mountain areas from his European upbringing to recreate Natural History. Such a distinctive approach, already championed by Humboldtian views of landscape character and the human impact of the Tropical Mountains —after his visit to *Chimburasu* in 1802 (Wulf 2015), has occupied the scholarly agency of geographers, ecologists, anthropologists and other scientists developing Karl Troll's *Landschaftsökologie* approach or *g*eoecology (e.g., Troll 1968; Sunyer 2000). Humboldt is immortalized with a bronze plaque that lays on a cairn at *Chimburasu*'s snowline (see Figure 3), including the words geoecology and montology recognized in *Kichwa* for the Andean world, in Spanish for Latin America, and in English for the Global North (Sarmiento 1999).

The ensuing ecological geographies of mountains were highly influenced by island biogeography theories of isolation, colonization and extinction. Later, the geographical ecologies of

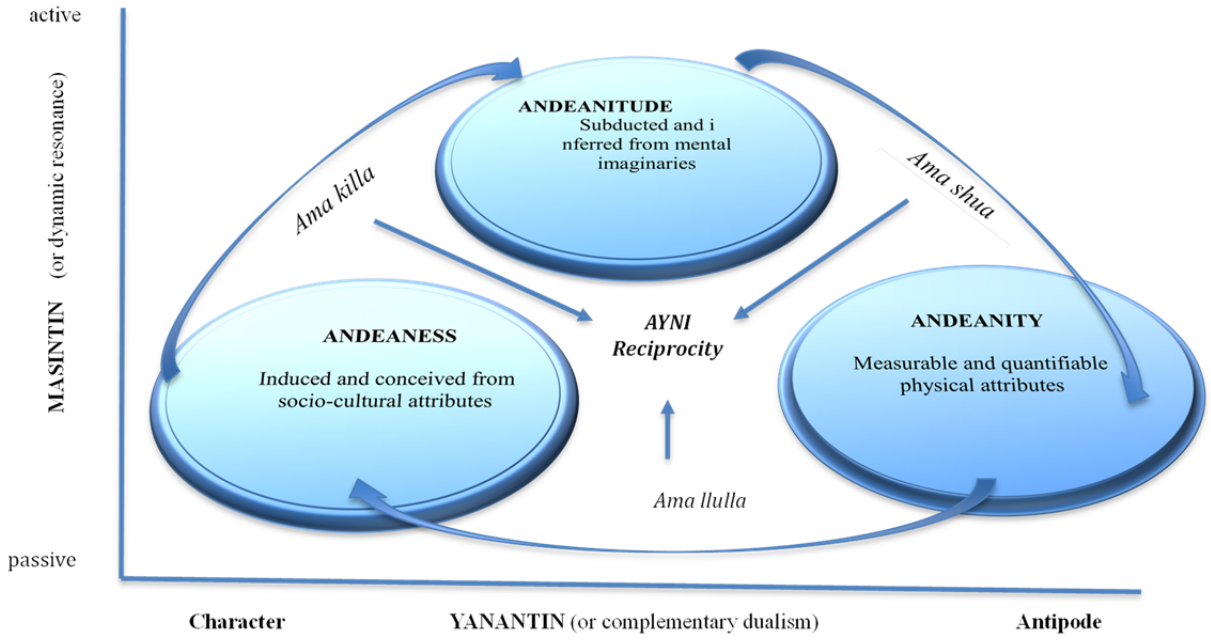

Figure 2 The Sarmiento Trilemma for Andean identity explains the formation of the sense of place informed by the trifecta of Andeanity, Andeaness and Andeanitude, describing the non-hierarchical and non-directional interaction of the factors affecting the individual response of reciprocal behavior guided by the three *Inka* commandments (do not steal, do not envy and do not be lazy) and influenced by the intensity of the response (*Masintin*) along the binary choice of complementary dualism of the selected character (*Yanantin*).

mountains were also cautiously developed as apolitical spaces with interest only to natural sciences, i.e., geology, flora and fauna (Ives 1980) until the realization of the political agency of conflictive power struggles was made evident not only by mining and agroindustry in the less-developed countries (Debarbieux and Rudaz. 2015; Zimmerer 1999) and the generation of endogenous perspectives (Sarmiento 2000), but also for the survival of anarchists and their way of non-conformism in 'Zomia', the little-known mountainous territory of Southeast Asian peasants and anarchists (Scott 2009).

Montology is predicted to become the venue for inclusion of alternative conservation ideas regarding mountains, far from its current emphasis on ecosystem services and biodiversity. With either indigenous or traditional ecological knowledge (TEK) that incorporates a third dimension, mountains are rooted also in the emotional geographies of biocultural heritage and the trope of sustainable, regenerative development (Zhong 2000; Bernstein 2015). Furthermore, the Humboldtian paradigm for horizontally segmented zones on the slopes has been augmented with the new montological approach of vertical integration. Important lowland-highland dynamics must encompass not only the biota or the gea, but also the human driver of farmscape transformation (Sarmiento 2002).

2.4 Mountains in a changing state of mind

The transition to montology from geoecology and landscape ecology gets fuzzy due to the need to include the non-linear pathways of organization of the Gestalt system of mountains, affected by farmscape transformation. It is imperative for us

Figure 3 The Chimborazo cairn with the bronze plate that immortalizes the contribution of Alexander von Humboldt to geoecology and montology. After the International Symposium of Sustainable Mountain Development in the Andes, organized by the Andean Mountain Association (AMA) in Ecuador in 1998. Photo by the author. Taken on-site at the installation of the tri-lingual plaque in 2003. A script from the English section is included above. Pictured are park rangers, the superintendent of the Chimborazo faunal reserve and workers from the signage company.

to grasp a new metaphor to understand the world (Lima 2013): instead of the arborescent description of *dendritic* representations, we need to assume a new network analysis of *rhizomic* representations of science, allowing horizontal symbiotic collaborations and bottom-up approaches instead of a rigid verticality of hierarchies and step-wise procedures of top-down practices (Sarmiento et al. 2013), because of the imperative of cross-cutting strategies to unify mountain realities.

The French term that describes the effects of unifying multisensorial inputs to create an emotional and fulfilling reality, *terroir*, comes to mind. The first sip of red wine, after the taster expertly has poured the carafe-rested wine into the glass, you can observe it descending the otherwise-invisible walls and see it bubbling on the expanded surface of the goblet. You inhale the aroma and wet the tip of the tongue before splashing the inner membranes of your mouth. The rush of sensations erases the line dividing wishes from memory. All things that was dear and cherished from the place of origin rush to meet your senses in that drink. *Terroir*, thus, is not only this flavor of fruit or that flower aroma that have integrated the fermented drink, but even the soil, the temperature, the sound of the rivulets, or the wind in the slopes of the vineyard. It encompasses the youthful voices of friends, the smoke of the cabin nearby, the eyes of the loved one, or even the ambiance of the cozy fireplace or the family diners at the table, all in a sensual memory landscape, accurate to microscopic detail, then, swallowed away.

Montology allows, like *terroir*, the possibility of integrating the tangible and intangible heritage of mountains into a Gestalt system of cognition that is organized with decentralization, non-linearity, multiplicity, interconnectedness, interdependence and cartographic anxiety of mountainscape memory. This essence of place given by montological practice allows for sacred geographies to partake in the decision making of conservation of mountain SESs and CASs (Sarmiento 2016a; Sarmiento and Hitchner 2017).

3 The road ahead: looking for paradise?

The National Geographic Society (NGS) has identified "GeoLiteracy" as the most important educational target for instruction to obtain geographic literate youth (Edelson 2011). I argue that montology must be incorporated as *the facto* trend to provide geoliteracy about the mountains of the world. By using montology, we are not only using the three I's of the GeoLiteracy approach (Interdependence, Interconnectedness, and Implications) in our study of mountains, but also, we are facilitating the inclusion of what in German is called *Gemütlichkeit,* a welcoming feeling of hominess, peace, and prosperity that you perceive in the place you love. It is neither the physical appearance of the house environment (*Umwelt*) of the mountain space, nor the imagined sensorial agreement of the home environment (*Lebenswelt*) of the mountain place, but it evokes the actual social construct of the shared built environment (*Mitwelt*) of the people of the mountainscape or SES (Westphal 2011). By using montology, we are inclusive of the whole content that affects mountain cognition. The fact that montology eases the categorization of positivistic science means that it allows the spatiotemporal identities (referred as "tempusculus" or individual "ecotope" at a particular time) to transgress across the guardrails of other disciplines (Tadaki 2017).

Therefore, montology should be recognized in tandem with our newly regained reverence for TEK coupled with western science to understand mountain dynamics as CASs (Allan 2018). It makes sense having transgressed referents as the only pathway to comprehend holistic mountain landscapes.

Moreover, the most difficult word to define in geography, *paradise*, —which in many cultures has often been associated with the earthly delights somewhere up there in the mountains (*c.f.:* Shangri La, Meru, Edin or *gan-ʿÊḏen*, Xanadu, Satoyama, Al-hallelujah, Sumakwaka Urku, Zomia, Tepuy, etc.)— exhorts scholars to continue the age-old quest of "finding paradise" as the enquiry of this utopian apex, peak, pinnacle space, summit place, landscape, inscape of the mountain ontological challenge of transdisciplinary mountainscapes. Thus, montology is herein made manifest.

4 Conclusion

Montology has served as an exemplar of transdisciplinary science of mountains. With the

use of geo/eco driven onomastics to translate conceptual frames without English terms, the need for transdisciplinary science to guide our current understanding of mountains is illustrated. The different examples of foreign words inform the competency of montology as a transgression of disciplinary fields and the referentiality of new epistemologies of mountainscapes. The use of foreign terms without direct English translation obviates the about-face of reductionist mountain cognition that divides pieces of knowledge into hard disciplinary silos, in favor of the holistic view of socioecologies found in the cross-cutting and convergent mountain science or montology..

The historicity of the term may relate more to a branding exercise than a completely new, alternative way to understand mountains. I invite mountain scientists to consider adding fundamental and applied research on the new approach in order to generate a stronger body of evidence in favor of montology. With the argument exhibited in the geoliteracy, ecoliteracy and sopholiteracy of current epistemologies, mountain ontology has been made evident anew, manifested as montology.

In the future, students and mountain scholars of the Greater South will actively develop the transdisciplinary science of montology for sustainable mountain lifescapes. After a paradigmatic shift in the study of mountain SESs, collective efforts will be required to develop sound understanding of the CASs of mountainscapes. It is also imperative to create new networks or to invigorate moribund practices of applied geography in order to translate hard and soft science into popular action. By allowing all research done about mountains to include and affirm the integrative work of montologists, we will secure the wise path towards long-term sustainability by the regenerative development of mountain SESs.

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