Applied Montology Using Critical Biogeography in the Andes

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More than most other landforms, mountains have been at the vanguard of geographical inquiry. Whether promontories, cultural works on slopes, or even metaphorical/spiritual heights, mountain research informs current narratives of global environmental change. We review how montology shifts geographic paradigms via the novel approach of critical biogeography in the Andes. We use it to bridge nature and society through indigenous heritage, local biodiversity conservation narratives, and vernacular nature–culture hybrids of biocultural landscapes (BCLs), focusing on how socioecological systems (SES) enlighten scientific query in the Andes. In our Andean study cases, integrated critical frameworks guide the understanding of BCLs as the product of long-term human–environment interactions. With situated exemplars from place naming, wild edible plants, medicinal plants, sacred trees, foodstuffs, ritualistic plants, and floral and faunal causation, we convey the need for cognition of mountains as BCLs in the Anthropocene. We conclude that applied montology allows for a multi-method approach with the four Cs of critical biogeography, a model that engages forward-looking geographers and interdisciplinary Andeanists in assessments for sustainable development of fragile BCLs in the Andes. *Key Words: Andes, biocultural landscape, critical biogeography, ethnobiology, intangible heritage, montology, páramo.*

山岳较其他诸多土地形式而言, 更处于地理学探问的前沿。无论是海角, 斜度的文化工作, 甚或是隐喻/精神性的高度, 山岳研究告知了全球环境变迁的当代叙事。我们透过安第斯山的批判生物地理学之崭新方法, 回顾山岳本体论如何改变地理范式。我们运用此一方法, 透过原着民族袭产, 地方生物多样性保存论述, 以及生物文化地景 (BCLs) 的风土自然—文化混合, 连结自然与社会, 并聚焦社会生态系统 (SES) 如何啓发安第斯山的科学探问。在我们的安第斯山研究案例中, 整合性的批判架构, 指引着对BCLs的理解, 作为长期人类自然互动的产物。透过地方命名, 野生可食用植物, 医疗植物, 神圣树木, 粮食, 仪式性植物, 以及动植物的因果关係之脉络性范例, 我们传达认可山岳在人类世中作为 BCLs 的必要性。我们于结论中主张, 应用的山岳本体论, 使得具有四大批判生物地理学的多重方法——一个让具前瞻性的地理学者和跨领域的安第斯山研究者参与至安第斯山中脆弱的 BCLs 之可持续发展评估的模式。 *关键词: 安第斯山, 生物文化地景, 批判生物地理学, 民族志生物学, 非物质袭产, 山岳本体论, 帕拉莫。*

Más que cualquier otro tipo de geoformas, las montañas han estado a la vanguardia de la investigación geográfica. Así sea en promontorios, trabajos culturales en las laderas, o incluso en alturas metafórico/espirituales, la investigación de montañas nutre las narrativas actuales del cambio ambiental global. Hacemos una revisión sobre el alcance de la *montología*, o estudio de las montañas, en la transformación de los paradigmas geográficos en los Andes al aplicar el novedoso enfoque de la biogeografía crítica. Lo usamos para tender un puente entre naturaleza y sociedad por medio de la heredad indígena, las narrativas locales sobre conservación de la biodiversidad y los paisajes bioculturales de híbridos vernáculos de naturaleza–cultura (BCLs), enfocándonos en la manera como los sistemas socioecológicos (SES) iluminan la indagación científica en los Andes. En nuestros estudios de casos andinos, el entendimiento de los BCLs como producto de interacciones humano–ambientales a largo plazo es guiado por esquemas críticos integrados. Por medio de ejemplos destacados a partir del proceso de nomenclatura de lugares, plantas silvestres comestibles, plantas medicinales, árboles sagrados, comidas, plantas rituales y la causalidad florística y faunística, hacemos notar la necesidad del conocimiento de las montañas como BCLs en el Antropoceno. Concluimos que una montología aplicada permite llegar a un enfoque multi-metodológico con los cuatro de la biogeografía crítica, un modelo que involucre a los geógrafos de miras abiertas y a especialistas interdisciplinarios sobre los Andes en evaluaciones del desarrollo sustentable de los frágiles BCLs de aquellas montañas. *Palabras clave: Andes, paisaje biocultural, biogeografía crítica, etnobiología, heredad intangible, montología, páramo.*

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Mountainscapes, or the appropriated interpretation of topographies and lifestyles, have driven epistemologies through elucidations of highland–lowland dynamics of many locales. These summit–abyss allusions drive environmental cognition of mountains while stimulating new ecoregional classifications worldwide (Lewis and Wigen 1997; Vallega 1999; Fouberg and Moseley 2015). Mountainous regions foster comparative studies incorporating not only the physicalities of the prominence but also verticality and accessibility (Allan 1986; Price et al. 2013) with significant human impacts; these human–environment relations define the heights in space–time in the public imaginary (Funnell and Price 2003; Welberry 2005; Macfarlane 2009). There is a Mountain *Problématique* that requires a "Mountain Agenda" (Messerli and Ives 1997, 455) with seven prerequisites: (1) perspective, (2) reciprocity, (3) devastation, (4) hazards, (5) awareness, (6) knowledge and research, and (7) policy, all of them pointing to the creation of *montology* (Neustadtl 1977). Montology is not only "the interdisciplinary study of the physical, chemical, geological, and biological aspects of mountain regions" but also is "the study of lifestyles and economic concerns of people living in these regions" (*Oxford English Dictionary* 2002).

Mountain landscapes' scientific disciplines, traditional cultures, and artistic creations suggest that these landforms are best understood as more than simply material entities of scientific curiosity; mountains are historically and socially constructed, and these constructions shape broader knowledge systems about society, place, and ecology (Debarbieux and Rudaz 2015). This fact explains the constructivist view using montology (Haslett 1998; Sarmiento 2000; Rhoades 2007), where cultural landscapes are central to define their identity, with place naming and biota distribution reflecting their sociopolitical and historical context (cf. critical biogeography) of Andean countries. Currently, epistemologies equate biodiversity with the physical setting and conservation policies favor tangible mountain biotas migrating upward with global warming (Borsdorf and Stadel 2015). Applying montology, we have increased understanding of the Andes as a socioecological system (SES) including the intangible heritage of the human driver of change.

Unlike chasing a chimera in the past (Messerli and Ives 1997), the cognate fields of biogeography, geoecology, and ethnobiology intertwine today, giving montology the wherewithal to define mountains holistically. Mountain research continues to elicit bridging the epistemological crevasse between the biophysical and the human models of "natural" (Gade 1996, 2016; Castree 2014) insofar as the biota distribution in the biocultural landscape (BCL; Cocks 2006; Hong, Bogaert, and Min 2014). Further, BCL requires longtime human manipulations. They are "complexes of biotic and cultural elements interconnected by historical and ecological evolutionary feedback, making them holistic assemblages yet dynamic and emergent social constructs with rich ancestral cultural practices" (Pungetti 2013, 56). Thus, mountains situate resource use with political ecology as sources of mineral and other environmental services and sinks of governance, marginalization, poverty, food (in)security, and globalized (in)equality within the hegemony of empire and indigenous affairs, historicity, and ethics (Rozzi 2015). Moreover, BCLs are made of

> majestic mountains, sacred forests, indigenous seeds, revered rivers which give life, renewal, inspiration and spiritual satisfaction. "The Source" is much more than just an awesome physical feature, it also comprises those mystical elements in a BCL that are less tangible, particularly with English language. It is the sacred essence of a natural spring that make it part of a creation story and not just a watery hole in the ground. It is the vast genetic universe inside of a single locally-adapted seed, or the connection you feel when you hike a special mountain and something just feels right, like you belong. A powerful natural energy emanates within a thriving BCL. To outsiders it might be overwhelming, or indiscernible, but to the stewards of that BCL it is as essential as the air, water and soil. (Christensen Fund 2016)

Most heights are prone for awe-generating sources whose intangibles comprise the "mountain heritage." For the traditionalist, the physical driver is pivotal: Descriptions of highland people and nature made by Humboldt in the 1800s are still as valid today as when biogeography was born (Wulf 2015). Mountains, however, are not just lowlands at higher elevations.

Montology emphasizes disciplinary hybrids to understand mountains holistically by challenging long-held beliefs. For instance, even basic premises for measuring the vertical dimension give montology a niche. Depending on the convention utilized, the "tallest mountain" on Earth might be either

Sagarmantha (Asia), Mauna Kea (Hawai'i, Polynesia), Chimborazo (South America), Denali (North America), Kosciuszko (Australia), Kilimanjaro (Africa), Sierra Nevada de Santa Marta (South America), or Mt. Lamlam (Guam, Micronesia). Depending on the choice of criteria, montologists might employ either (1) elevation above sea level, (2) continuous vector slope, (3) planetary radius toward the troposphere, (4) edifice prominence, (5) *Z* proportion of *X* length, (6) *Z* proportion of *Y* width, (7) shore/summit direct line of sight, or (8) trench/summit ratio (Sarmiento 2016a). This physical disaccord has a cultural counterpart in the disputed names of some peaks, most notably *Denali* (Mt. McKinley), *Sagarmantha* (Mt. Everest), and *Tayrona* (Sierra Nevada de Santa Marta; see Figure 1). Some groups deem demonic buttes as the highest mountains, such as Devil's Tower for the *Arapaho* in the United States or *Auyán-Tepuy* for the *Pemón* in Venezuela. Other groups consider menacing volcanoes as the highest mountains, such as *Reventador* for the *Cofán* in Ecuadorian Amazonia or *Popocatepetl* for the *Mixtec* of the central plateau of Mexico. Hitherto, the Western predicament of conventionalism favored scientific over vernacular descriptors. This practice is currently contested in the Global South, however (Gudynas 2013).

Montology as a New Paradigm

Social construction of mountains grapples with paradigms that are undermined by vapid interpretations of desultory phenomena; the resulting poorly scrutinized rhetoric misguided conservation, inscribing mountains as protected areas only if they were pristine or assessing highland communities as if they were peacefully bonded (Berkes, Folke, and Colding 2000; Arpin and Cosson 2015). Their mythical Shangri-La, Xanadu, Meru, or even Zomia are imagined paradises for the tired, the lost, the pure, or the anarchist on mountainscape territories. Mountain imaginaries thus vary according to geographic, scientific fashions without theoretical grounding in complex BCLs (Gould 1979; Bradshaw and Bekoff 2001; Koutsopoulos 2011; Fu and Jones 2013; Rozzi et al. 2015; Convery and Davis 2016).

The waves of paradigmatic change in mountain geography provide alternative ways of knowing, especially from traditional ecological knowledge (TEK) handed down through generations, often through songs, stories, and beliefs (Berkes, Folke, and Colding 2000). TEK is kept by indigenous, metis, mestizos, and other locals, creating sustainable lifescapes with time-tested practices that exemplify mountains as BCLs (Allan, Knapp, and Stadel 1988). Mountain people are developmental subjects, as required by the new spiritual dimension, the so-called sacred ecology transition, while societies become affluent. This transition reflects an inverse Kuznets environmental curve for Earth stewardship, as opposed to demographic or forestry transition curves of environmental degradation (Figure 2). By looking through a critical lens at sacred ecology (Berkes 2012; Rozzi et al. 2012), the financially richest postindustrial economies with disposable income can better attune with a comprehension of BCLs (Hong, Bogaert, and Min 2014) by increased spiritual awakening.

Shifting Paradigms and Mountain Methodologies

The topographic, geodesic, and chorological maps of mountains no longer suffice. New tools in the montologist's arsenal include telemetry, remotely sensed data, relational databases with geographic information systems, 3D plotting, modeling, geovisualization, flight-in software, ground-penetrating radar, and cloud stripping networks (Sarmiento, Box, and Usery 2004). These revolutionary research instruments, informatics, and analytics, although offering a new, faster mode of mountain cognition, also benefit from anecdotal, ground truthing, and direct observational data gathering and local knowing (Graham and Shelton 2013). The role of TEK itself has undergone its own paradigmatic shift, going from the vertical "dendritic" approach of top-down, reactive fixes to problems into a horizontal "rhizomic" approach of bottom-up, proactive planning for development with participatory communal benefits (Guattari 1995). In postcontemporary discourse, the conservation toward sustainability paradigm emphasizing biocultural heritage replaces the prior paradigm of conservation toward nature pristine that emphasized wilderness (Estevez et al. 2010; Rotherham 2015; see Table 1).

Two methodological aspects of the paradigmatic shift in the Andes bring currency to BCLs: (1) demystifying of hinterlands and (2) reaffirmation of mountain identity. Throughout the tropical Andes, a plethora of *pueblos originarios* struggle to maintain

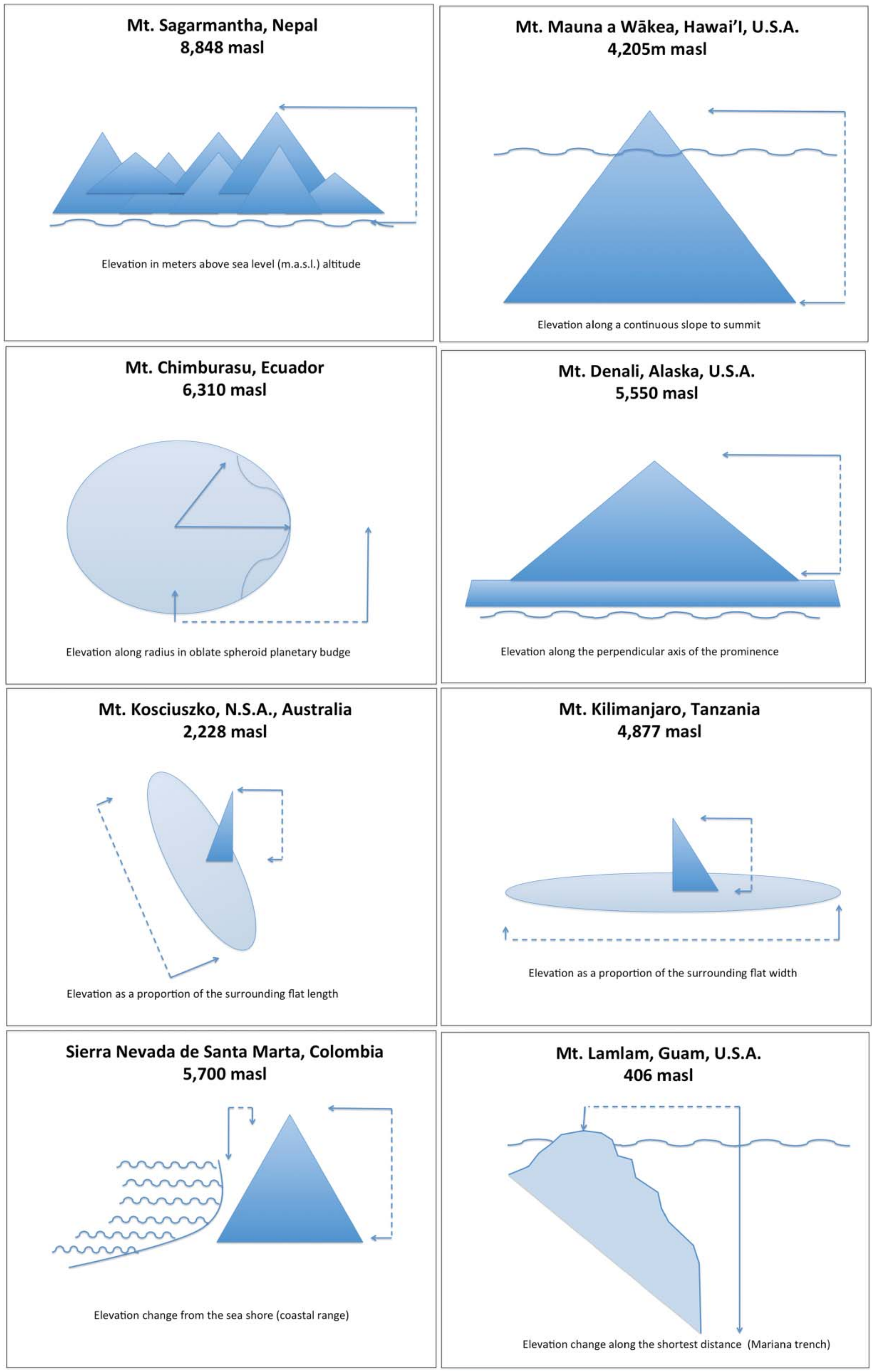


Figure 1. Conceptual models used to consider the eight tallest mountains on Earth. A simple convention of choice plays a major role in the new understanding of mountain socioecological systems. (Color figure available online.)

their identity and sovereignty amidst globalized acculturation; they recently gained political clout and social agency at the national and local levels, as in the community conserved areas and *resguardos indígenas* (e.g., Rozzi 2012; Sarmiento and Hitchner forthcoming). Because mountains harbor high

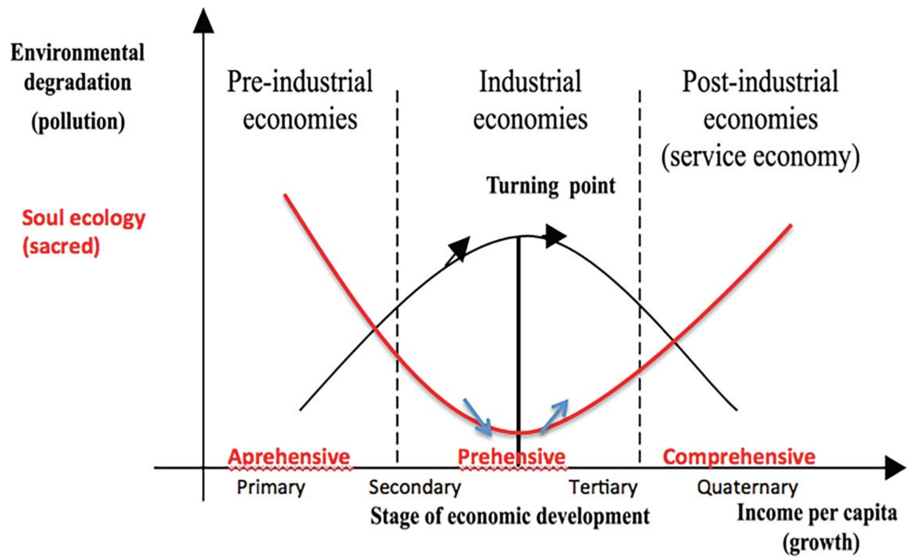


Figure 2. A quadratic equation representing the inverse Kuznets environmental degradation curve exhibited by the changing soul ecology dimension of the sacred, as societal forces move from apprehended cultures of primitive, preindustrial stages to prehensive, modern industrial cultures and to comprehensive, postindustrial stages. *Source*: Panayotou (1993). (Color figure available online.)

biodiversity values and provide the majority of landscape services (Bastian et al. 2014), we posit the notion of highland identity to incorporate insights from folk literature and eco-critical narratives of regional saliency for climate change scenarios, particularly those dealing with Andean biota affected by global warming and rural-to-urban migration.

Table 1. Paradigms of biogeography, including main exponents and the timeline period of major shifts in the different scientific trends observed

Shifting paradigm	Period	Scientific trend	Main exponent
Geodesic shape	1736	Planetocentric	Charles Marie de La Condamine
Binomial systematics	1738	Divine taxonomic order	Carl Linnaeus
Natural history	1777	Phenomenology	Georg Adam Forster
Altitude/latitude	1802	Romanticism	Alexander von Humboldt
Plant taxonomy	1817	Revisionism	Agustin-Pyramus de Candolle
Natural selection	1838	Pragmatism	Charles Darwin
Natural selection	1858	Spiritualism	Alfred Russel Wallace
Field biology	1863	Mimetism	Henry Bates
Plant ecology	1890	Reductionism	Carl G. Oscar Drude
Phytogeography	1896	Continentality	Heinrich G. Adolf Engler
Zoogeography	1899	Dispersal	Robert F. Scharff
Chorology	1907	Utilitarianism	Alfred Hettner
Landscape ecology	1939	Positivism	Carl Troll
Historical geography	1952	Culturalism	Carl O. Sauer
Island biogeography	1967	Insularity	Robert MacArthur
Evolutionary biology	1970	Phylogeneticism	Ernest Mayr
Ecosystem ecology	1971	Holism	Eugene P. Odum
Sociobiology	1975	Altruism	Edward O. Wilson
Bioenergetics	1995	Emergism	Odum, Odum, & Odum
Biodiversity	1998	Conservationism	Norman Myers
Human impact	2005	Integrationism	Jared Diamond
Montology	2007	Postmodernism	Robert Rhoades

Criticality of Mountain Biogeography Theory

Biogeography falls within physical geography. Conventional mountain biogeography describes why organisms occupy the vertical gradient (Resler and Sarmiento 2016), with inferences on distribution and migrations, such as when finding the equilibrium between colonization and extinction on insular peaks (MacArthur and Wilson 1967). Linking vegetation with climate and elevation was the driver of physiographic studies of mountain lands. Island biogeography theory, however, did not employ critical approaches in science and society (Slaughter and Rhoades 2005) needed to (re)present the interweaved BCL fabric matrix (Sarmiento 2012). We agree with Lave et al. (2014) when affirming "Critical Physical Geography (CPG) combines critical attention to power relations with deep knowledge of biophysical science or technology in the service of social and environmental transformation" (2). In montology, it is clear that critical biogeography necessitates the political ecology angle that must be emphasized in the training of geographers (Castree 2000). Separating nature and culture is impracticable in SES: "Socio-biophysical landscapes [cf. BCLs] are as much the product of unequal power relations, histories of colonialism, and racial and gender disparities as they are of hydrology, ecology, and climate change" (Lave et al. 2014, 6).

Andean biogeography played a key role in our understanding of mountain systems. Humboldtian views included not only field measurements and experimentation in geoecology but also poetry and nature paintings (Wulf 2015). Tropandean BCLs henceforth became the "birthplace of ecology" and remain a powerful inspiration for montological research (Figure 3). The name *Andes* itself comes from terracing, the impressive manufactured feature that conquistadors encountered exploring the cordillera or *Ritisuyu*. Critical biogeography explains the essence of BCLs in the Andean Holocene (White 2013).

Figure 3. The biocultural landscape is exemplified by Mt. Chimburasu (in Spanish, Chimborazo) as the tallest mountain on Earth and as a telluric presence of this *Apu* in mountain communities. The *páramo* and the *llamakuna* represent the inseparable nature–culture coupling of biocultural heritage, similar to what Humboldt found in 1802. *Photo*: Fausto O. Sarmiento, 1998. (Color figure available online.)

Regional Saliency of Montological Research

Describing the Equatorial Andes, Humboldt wrote of palm trees in the inter-Andean valleys, without considering that three centuries ago the *Inka*'s northward expansion had introduced the royal palm (*Parahubaea cocoides* Burret) as a marker of *Inka* nobles settled toward the Empire's confines. Today those palms cannot be found wild in Ecuador but still decorate the entrance to homesteads and central plazas of mountain villages as the *coco chileno* palm. Unlike the Columbian Exchange of 1492 (Crosby 2003), the pre-Columbian exchange of antiquity awaits scientific scrutiny. Moreover, Helferich (2011) wrote that Humboldt noted extensive *páramo* grasslands above the treeline, but he did

Table 2. Examples of how local viewpoints influence current understanding of the Andes mountainscape.

Field of knowledge and topical area	Actual term *Latinized origin*	Popular meaning *Hegemony*	Vernacular meaning *Indigenous revival*
Place naming: *how the name influences common understanding*			
Onomastics	Andes cordillera *Antisuyu*	A tribe said to live east of Cuzco	*Ritisuyu*: the zone of high mountains with snow in the upper reaches
Political ecology	Río Santa Rosa *Roman sanctorum*	Honoring a Catholic saint from Lima, with no ecological value	*Chakapata*: the description of the actual ecological character of the river
Etymology	Páramo *Alpine para-moor*	Highland grasslands	*Paramuna*: the meteorological condition of cold drizzle
Medicinal plants: *how usage guides common practice*			
Placebo effect	Cedrón *Aloysia citrodora*	Lemon verbena tea	*Shunguyaku*: infusion to calm your nerves
Energy boost	Coca *Erythroxylon coca*	Illegal plant for high alkaloid content	*Kuka*: sacred leaf to offer limitless energy and reduce hunger and thirst
Disinfectant	Sangre de drago *Croton lechleri*	Sap with antibacterial properties	*Draku*: sap with curative antiseptic properties
Sacred trees: *how myth explains the existence in place*			
Origin	Lechero *Euphorbia laurifolia*	Fence post and browsing source	*Pinllu*: sacred tree of the *Atawallu runakuna* of Ecuador
Oracle	Araucaria *Araucaria araucana*	Monkey-puzzle tree	*Pewen: Mapuche* sacred food (*ngülliw*) or drink (*chavid*)
Destiny	Arbol de dios *Buddkeja incana*	Stunted tree of the highlands	*Kiswar*: sacred tree for the *Inka*, a source of awe, inspiration, and timber
Foodstuff: *how utilization favors traits in place*			
Nutrition	Quinoa *Chenopodium quinoa*	The Andean cereal, now popular in organic food stores	*Kinwa*: sacred food of the *Inka* with domesticated hybrids
Wholesome	Mashua *Tropaeolum tuberosum*	The root from the altiplano, aphrodisiac	*Maswara*: sacred food of the *Aymara*
Security	Chuño *Solanum tuberosum andinum*	Freeze-dried potato of the Andes	*Chuñu*: potatoes pressed and dehydrated in the cold mountain air
Rituals: *how observance and tradition inform practice*			
Psychotropic	Ayahuashca *Banisteriopsis caapi*	Native psychoactive brew	*Yagué*: Spiritual medicine for the Pan Amazonian tribes of the verdant
Respect	Alubillo *Toxicodendrum striatum*	Manzanillo, the poison ivy of the Andes	*Ninakaspi*: a guardian who can hurt with allergic rashes
Cleansing	Ortiga *Caiophora superba*	Ortiga, the nettle of the Andes	*Itapalla*: rituals for cleansing and traditional medicine of *yachag*
Flora causation: *how plants are distributed in the landscape*			
Planting	Paja *Calamagrostis*	Páramo pajonal, a wet grassland system	*Ichumanta*: Planted where grazing pressure is felt after burning for clearings
Selection	Aliso *Alnus jorulensis*	Alder growing in disturbed coves	*Jatun Kaspi*: Agri-forestal system grew on the terraces along with other crops
Externality	Cacaotillo *Miconia robinsoniana*	Shrub-dominated area in the mountains of the Galapagos Islands	*Colquita*: Its appearance in the fossil record is recent, just after introduced cattle grazing
Fauna causation: *how animals are distributed in the landscape*			
Domestication	Llama *Lama glama*	Beast of burden	*Llama*: Provides everything but milk to Andean societies
Selection	Cobayo *Cavia porcellus*	Pets for laboratory experiments	*Kuy*: Clean the homes and provide meat for Andean households
Externality	Oso de anteojos *Tremarctos ornatus*	Indicator species for the Páramo ecosystem	*Ucumari*: an inhabitant of the cloud forest belt, uses the grasslands to scout for terrestrial bromeliads

not mention that throughout colonial times, the straw from *paja* (*Calamagrostis* spp., *Festuca* spp., *Stipa* spp.) was a most valuable commodity for construction, roofing, textile, handcrafts, transportation, insulation, and fodder to sheep, cattle, and goats introduced with the "mediterranization" of the Andean farmscape. This made *pajonales* an attractive economic alternative in the highlands, leading to an anthropogenic, planted, and burned grassland and heathland or moorland composed of pyrophitic species. Following the views of pastoral thinkers from Europe at the time, Humboldt recorded extensive grazing by some 40,000 heads of sheep in the *páramos* of Antisana (Bunkse 1981) as his utopic portrait of the Andes, maximizing the catholic bucolic ideals, yet forgetting the devastation due to overgrazing, ignoring the manufactured BCL evidence, and affixing the segmented view of tropical mountains.

Some species remind us of intricate coupled nature–culture interactions (Gade 1999). Fauna–flora interactions better exemplify what is now generally accepted: The human impact of change during the Holocene is responsible for what we see today in Andean mountainscapes (Orlove 1985; Sarmiento 2002; Tellkamp 2014). Inter-Andean valleys are now lacking natural vegetation and are composed of a BCL matrix of crops and introduced grasses, hedges, and patches of planted woodlots of pine and eucalyptus, all interacting with cows, sheep, goats, chickens, and the native *kuy* or guinea pig (*Cavia porcellus* Linnaeus). The misnomer of *kuy* as "African swain" reflects a critical hegemonic discourse on how and why species have been named without regard to the vernacular. Critical biogeography, thus, using the 4 Cs multimethod, explains how fortuitous distributions can only partially account for spatial interpretations and that novel ways should provide not only *content* (e.g., the cattle egret, *Bubulcus ibis* Linnaeus, as a disperser) but also *continent* (its distributional range along herds of livestock on wet American grasslands after their arrival in North America in 1941 from Africa), *contestation* (e.g., why all cattle egrets are now gone from Andean wetlands, reflecting cattle ranching woes and climate change), and *conveyance* (e.g., their inclusion on the bird list as emblematic of the grasslands, although in reality cattle egrets are ephemeral), thus making it human-dependent as driving change (see Table 2).

Ibarra et al. (2012) used the iconic Andean condor (*Vultur gryphus* Linnaeus) to translate the

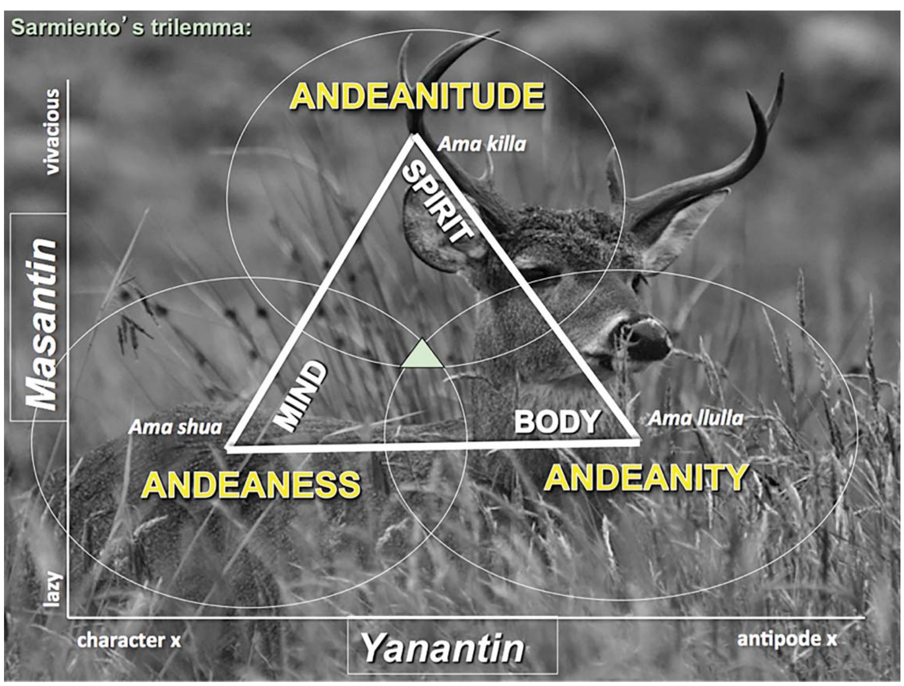


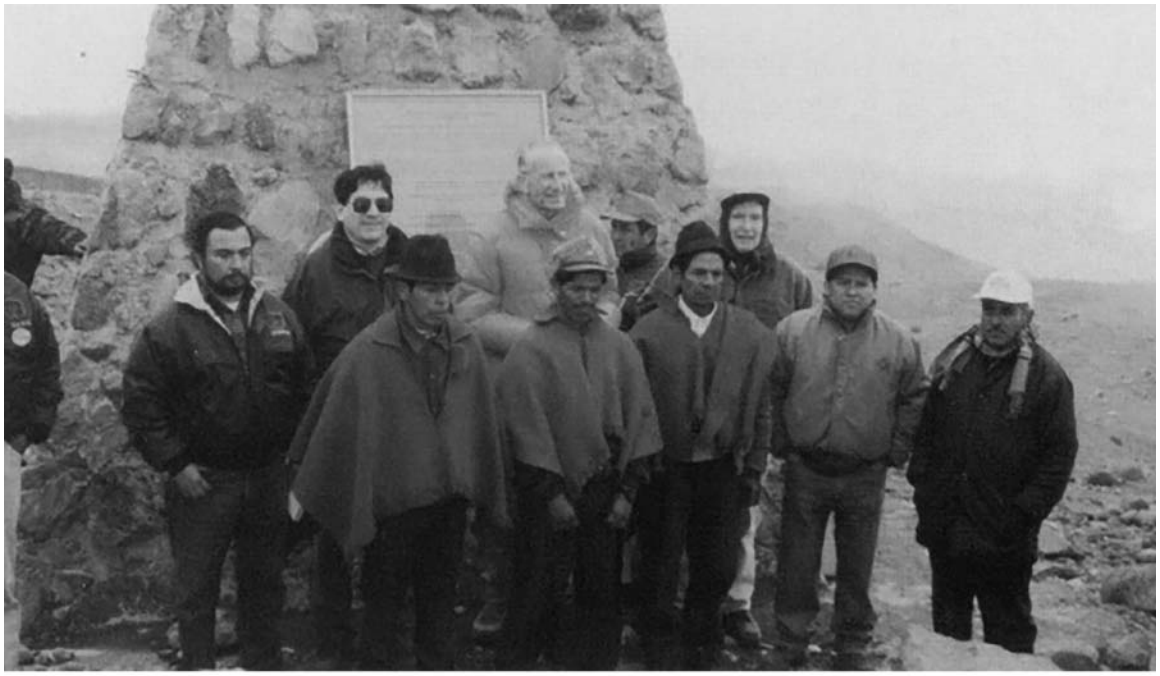
Figure 4. An example of the white-tail deer as an iconic biocultural landscape marker that aids in the construction of the Andean identity. Note the polarity vector of *Yanantin* being influenced by the energizing vector of *Masantin* affecting the trifecta of Andeanity, Andeaness, and Andeanitude to understand the vortex of being Andean (*Lo Andino*). *Source*: Adapted from Sarmiento (2015). (Color figure available online.)

cosmological vision onto the BCL, which is essential for Andean stewardship (Rozzi 2004). In the same vein, the Andean Lapwing (*Vanellus resplendens* Tschudi) is a proxy for farmscape transformation, abandoning the nature–culture dichotomy in favor of a BCL perspective that reciprocally explains the nature–culture continuum (Sarmiento 2016b).

Taxonomic groups of species of wide distribution and diverse cultural meanings along, across, and within the Andes, like the *caracaras* (e.g., *Milvago chimango* Vieillot, *Caracara plancus* Miller, and *Phalcoboenus megalopterus* Meyen), reflect the human–environmental interaction from the lowlands toward the highlands, including Amazonian (McMichael et al. 2012) and marine-coastal environments (Pizarro, Anderson, and Rozzi 2012). Other species such as llamas (*Lama glama* Linnaeus; May 2015) and white-tailed deer (*Odocoileus virginianus* Zimmermann; Sarmiento 2015) exemplify the bridging of the social and biological sciences from the critical biogeography perspective of Andean identity by integrating mysticism and the spiritual dimension (Figure 4). Barreau et al. (2016) showed

Figure 5. Gathering *piñones* (seeds of the monkey-puzzle tree *Araucaria araucana* Molina) and other wild edible plants. Restricted access to Andean temperate forests, due to land grabbing and biodiversity preservation initiatives, is endangering the continuity of this practice for the *Mapuche* people. *Photo*: J. Tomás Ibarra, 2014. (Color figure available online.)

how land grabbing, lack of access to mountain forests, and formal Chilean school regime have eroded plant knowledge transmission to children, thereby limiting local food sovereignty (Figure 5). In northwestern Argentina, González et al. (2014) recognize quinoa (*Chenopodium quinoa* Willd) as a "superfood" highlighted by the International Year of Quinoa in 2013. This United Nations



(A)

ALEXANDER VON HUMBOLDT–23 JUNE 1802

IN MEMORY OF HIS CONTRIBUTIONS TO MOUNTAIN GEOECOLOGY

The Andean Mountains, especially Chimborazo, stirred the imagination and scientific labor of this great man. In addition to his many other contributions, it was in this tropandean landscape, beneath the eternal snows of our majestic volcano, where he laid the foundations of "mountain geoecology," or "montology," that continues to mold world society. The Rio de Janeiro Earth Summit of 1992 ensured international recognition of the importance of our mountains, in part from United Nations University research, and created an awareness that is finally transcending into action. This advance culminated in November 1998, when the General Assembly of the United Nations declared AD 2002 as the International Year of the Mountains

"FOR A BETTER BALANCE BETWEEN MOUNTAIN ENVIRONMENT, DEVELOPMENT OF RESOURCES, AND THE WELL-BEING OF MOUNTAIN PEOPLES"

Chimborazo, the birthplace of Mountain Geoecology
December 15, 1998

Indigenous Committees of Chimborazo
Jack D. Ives (IMS/UNU) International Mountain Society
Fausto O. Sarmiento (AMA) Andean Mountains Association
Lawrence S. Hamilton (WCPA-IUCN) World Conservation Union, Commission on Protected Areas: Mountains
Bruno Messerli (IGU) International Geographical Union
Juan Hidalgo (CEPEIGE) Pan American Center for Geographical Studies and Research
Patricio Hermida (INEFAN) Chimborazo Reserve Manager

(B)

Figure 6. (A) Montology plaque at the mountaineering refuge at the snowline of Mt. Chimburasu, Ecuador. Pictured among local indigenous leaders and governmental officials are mountain scientists who promote montological research. (B) Text of the English version of the montology plaque on the cairn of Mt. Chimburasu. The Spanish and *Kichwa* versions were included to relate to regional, national, and local audiences.

recognition is due to its high-quality protein content and its plasticity for climate change adaptation on marginal and saline lands of the Altiplano.

Conclusion

Mountain investigation begs the inclusion of conventional hard and modern soft science, including indigenous and TEK, to create the new transdisciplinary science of montology. Just as environmental geography is envisioned to capture the interaction of physical and human dimensions in the essence of place, so is montology intended to capture the meaning of mountains and their lifescape. With examples of Andean plants and animals, the coupling of human–environment interactions has shown integration of physical, psychological, and spiritual dimensions to understand mountain territoriality on biota distribution. In addition, the transdisciplinary montological approach includes little-known facts from indigenous cosmologies and habitual usages that help better protect charismatic, even totemic, species from endangerment. Critical biogeography, hence, must drive research in mountain scenarios of climate change and biota distribution (Figure 6).

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