Agave americana and *Furcraea andina*: Key Species to Andean Cultures in Ecuador

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Abstract

Background: The rich Agaveae-based culture that exists in the Ecuadorian Andes is little known. Wild and cultivated rosettes of *Agave americana* and *Furcraea andina* coexist in arid Andean landscapes. *A. americana* is considered an introduced species to Ecuador.

Questions: What are Agaveae use patterns and cultural importance in the Ecuadorian Andes? Is the ethnobotanical significance of *Agave* in Ecuador comparable to that in Mexico and other Andean countries?

Species studied: *Agave americana, Furcraea andina*

Study site, dates: Ecuadorian Andes, 2016.

Methods: Semi-structured interviews to Agaveae users (37) and a review of literature on ethnobotanical research conducted in Ecuador since the 18th century.

Results: *A. americana* is more diversely and widely used than *F. andina* (124 *vs* 36 uses and 548 *vs* 140 use records, respectively). The versatility of *A. americana* lies in its *mishki* (sap extracted from its heart) which has multiple medicinal, edible and ceremonial applications. We found significant variation of its use patterns throughout the region. The main use of *F. andina* as a source of fiber is disappearing. Most productive initiatives involve *A. americana* (92 %, n = 53).

Conclusion: The importance of *A. americana* in the Ecuadorian Andes is comparable to that of agaves in Mexico, but not to its importance in other Andean countries where it is used sporadically. It can be considered a cultural keystone species. *F. andina* could have had that role in the past. *A. americana* versatility and availability through cultivation could explain why, irrespective of whether or not it is introduced, it remains an icon of identity and cultural cohesion in the Ecuadorian Andes.

Key words: *Agave americana,* Agaveae Ecuador, cultural keystone species, Ethnobotany, South American Agaveae.

Resumen

Antecedentes: Es poco conocida la rica cultura basada en Agaveae que existe en los Andes ecuatorianos. *Agave americana* y *Furcraea andina* son especies silvestres y cultivadas que coexisten en paisajes áridos andinos. *Agave americana* es considerada una especie introducida en Ecuador.

Preguntas: ¿Cuáles son los patrones de uso y la importancia cultural de Agaveae en los Andes ecuatorianos? ¿Es la relevancia etnobotánica de *Agave* en Ecuador comparable con la que tiene en México y en otros países andinos?

Especies estudiadas: *Agave americana, Furcraea andina*

Sitio y años de estudio: Andes ecuatorianos, 2016.

Métodos: Entrevistas semi-estructuradas a usuarios de Agaveae (37) y revisión de literatura de investigaciones etnobotánicas realizadas desde el siglo XVIII.

Resultados: *A. americana* es más diversa y ampliamente utilizada que *F. andina* (124 *vs* 36 usos y 548 *vs* 140 registros de uso, respectivamente). La versatilidad de *A. americana* se basa en su *mishki* (savia extraída de su corazón) que tiene múltiples aplicaciones medicinales, alimenticias y ceremoniales. Encontramos una variación significativa de sus patrones de uso a través de la región. El principal uso tradicional de *F. andina* como fuente de fibra se está perdiendo. La mayoría de iniciativas productivas involucran a *A. americana* (92 %, n = 53).

Conclusión: La importancia que tiene *A. americana* en los Andes ecuatorianos es comparable con la que tienen los agaves en México, pero no en otros países andinos donde es usada esporádicamente. Ésta puede ser considerada como una especie cultural clave. *F. andina* pudo haber tenido ese rol en el pasado.

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La versatilidad de *A. americana* y su disponibilidad por ser cultivada, podrían explicar por qué, independientemente de que sea una especie introducida o no, sigue siendo un referente de identidad y de cohesión cultural en los Andes del Ecuador.

Palabras clave: *Agave americana,* Agaveae Ecuador, Agaveae sudamericanos, especies culturales clave, Etnobotánica.

Agave and related species are a group of American monocotyledons (family Asparagaceae, subfamily Agavoideae, group Agaveae: ex Agavaceae s.s.) consisting of 10 genera and 340 species (Eguiarte *et al.* 2000, Bolger *et al.* 2006, Stevens 2001. Central Mexico is recognized as the center of diversity of Agaveae (Eguiarte *et al.* 2000, Bolger *et al.* 2006, Colunga-GarcíaMarín *et al.* 2017). Their importance in the development of Mesoamerican cultures in arid zones is widely recognized (Parsons & Darling 2000, García-Mendoza 2007, Pardo-Briceño 2007, Colunga-GarcíaMarín *et al.* 2017). However, little is known about the rich indigenous and mestizo Agaveae-based culture in the Ecuadorian Andes. This research aimed to investigate the use patterns of these plants at the southern range of their distribution.

Pardo-Briceño (2007) argues that the long relationship between agaves and humans dates back approximately 10,000 years, to the beginning of agriculture in America. Agaves have been used for their fibers, as well as a food and beverage source, its domestication, together with maize, is believed to have been a determining factor in the development of cultures in Mesoamerica (Parsons & Darling 2000, Pardo-Briceño 2007). *Pulque*, a drink made from the fermentation of the sweet sap extracted from the heart of the mature (flowering) rosette of some agaves, was considered to be a drink of the gods by the Mexicas (Broda 1982). The sap, known as *aguamiel* or honeywater in Mexico, and as *chawarmishki* or *mishki* in Ecuador, has been used as a sweetener and even as a substitute for water in extremely dry regions (Cerón 1994, García-Mendoza 2007).

Archaeological evidence suggests that the relationship between Agaveae and humans in Ecuador has existed since the Period of Integration (1,000-1,450 C.E.). Evidence includes ceramic vessels consisting of a spherical body and three feet in the shape of an agave leaf attributed to the Andean cultures of Cañari and Puruha (Proyecto Chasqui 2016, Mindalae Museum pers. obs. of L. de la Torre).

Spanish chroniclers from the Colonial period held the agaves in high regard due to their variety of uses and importance, and compared the plantations in Mexico to vineyards in Europe (Pardo–Briceño 2007, Bonifaz 2012). In South America, in *Comentarios Reales de los Incas*, first published in 1609 (de la Vega 2004), Garcilaso de la Vega (1539-1617) mentioned the "*árbol de maguey" (Agave americana* L.) and reported on its invigorating, nutritional and medicinal properties, the preparation of "honey, vinegar, and strong concoctions", its use as a source of fiber for the manufacture of ropes, hunting nets, footwear or clothing, and its use by indigenous women to make their hair long and lustrous (de la Vega 2004). In the *Historia del Reino de Quito en la América Meridional*, first published in 1789 (de Velasco 1977), Juan de Velasco (1727-1792) explained the indigenous practice of preparing *pulque* from "*maguey or cháhuar"* to obtain a honey to treat animals as well as its cultivation as live fence, and highlighted the utility of the fiber of the "*maguey blanco*" (*Furcraea andina* Trel.) to make ropes, sacks, and soap (De Velasco 1977). Both species mentioned (*A. americana* and *F. andina)* are the only Agaveae that occur in the Ecuadorian Andes, both wild and cultivated and are conspicuous in dry valleys (Jørgensen & León-Yánez 1999).

It is known that these species are still used in this region (Cerón 1994, de la Torre *et al.* 2008, Bonifaz 2012). However, the importance that Agaveae have and have had in Andean cultures, and whether that importance is comparable to that observed in Mesoamerica, has yet to be assessed. In this study we evaluate the cultural importance of Agaveae in the Ecuadorian Andes. The identification and focus on culturally significant species or cultural keystone species, defined as those species that have a high symbolic value for a people and prominently shape its cultural identity due to its fundamental role in diet, as a source of materials and medicine, and its use in spiritual practices (Cristancho & Vining 2004, Garibaldi & Turner 2004), could improve the success of biocultural conservation and ecological restoration efforts (Cristancho & Vining 2004, Garibaldi & Turner 2004).

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Eliot Logan-Hines: Conception or design of the work, data analysis and interpretation, critical revision of the article, final approval of the version to be published, agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately researched and resolved.

Taking into account that *A. americana* is believed to have been introduced from Mexico (Jørgensen & León-Yánez 1999), while *F. andina* is a native species (Gentry 1982, Jørgensen & León-Yánez 1999), and in order to contribute to the knowledge of the origin and distribution of Agaveae and their uses in South America, we sought to compare: 1) the use of these two Agaveae species in the Ecuadorian Andes, 2) the use of *A. americana* in Ecuador to its use in other Andean countries where this species grows (eMonocot 2017, GBIF 2017, Tropicos 2017) and is considered introduced as well (Peña 1976, Tirado 2002, Venero-González 2006, Bernal *et al.* 2015), and 3) the use of *A. americana* in Ecuador and Mexico, the country known as the Agaveae center of diversity and culture (Eguiarte *et al.* 2000, García-Mendoza 2007, Colunga-GarcíaMarín *et al.* 2017).

Materials and methods

Distribution, description and biology of the species studied. Furcraea andina and *Agave americana* are the only species of Agaveae that grow wild in the Ecuadorian Andes, where they coexist (Jørgensen & León-Yánez 1999). *A. americana* is a native of Mexico and the southern United States and considered introduced in Central and South America; it can be found in all of the Andean countries from Colombia and Venezuela to Bolivia (eMonocot 2017, GBIF 2017, Tropicos 2017). The distribution of *F. andina* is restricted to Ecuador, Peru and Bolivia (eMonocot 2017, GBIF 2017, Tropicos 2017). Both *A. americana* and *F. andina* are long lived, monocarpic succulent plants that form rosettes. Their rosettes grow for several years, and after developing an immense inflorescence, they die (Rocha *et al.* 2006). These species are also capable of clonal reproduction with colonies surviving for several generations (Rocha *et al.* 2006).

Vegetative propagation of *A. americana* occurs mainly through offshoots that emerge from its rhizome system (Gentry 1982). The plant is a wide rosette of tough leaves that reach 5 m in diameter and 2 m in height; leaves have serrated edges, and straight, curved (or slightly curved) thorns, and a large, sharp apical thorn; it takes between 7-17 years for the rosette to reach its reproductive phase (Cerón 1994, Pardo-Briceño 2005). The time of blooming, and subsequent sap harvesting, can change depending on its care: water and nutrients speed up the process while pruning the leaves delays it (de la Torre *et al.* in prep). The inflorescence is a panicle that can reach heights of up to 10 meters, with dense clusters of rigid green-yellow flowers (Cerón 1994: Figure 1). In Ecuador, these are pollinated by hummingbirds (*Chaetocercus mulsant*, *Chlorostilbon melanorrhynchus*, *Colibri coruscans*, *Lesbia victoriae* and *Patagona gigas),* as well as insects, including bees, bumble bees, butterflies, and dragonflies (Cerón 1994, Ortiz 2003). Birds, such as *Parabuteo unicinctus* and *Falco sparverius*, perch on the flower stalks (pers. obs. of L. de la Torre).

Vegetative propagation of *F. andina* occurs through bulbils (Bailey 1915). The plant is a green rosette whose leaves while weaker than those of *A. americana,* are similarly sized, and have spines along the edge of the entire leaf, or sometimes only from the middle section to the tip; leaves have a hard and pointed apex (Bailey 1915, Cerón 1994). This species generally produces its inflorescence in its third year but, reproduction can be delayed by many years depending on care (Bailey 1915, Cerón 1994). The plants from which leaves are harvested to obtain fibers can last decades without flowering (R. Rodríguez 2016 pers. comm.). The inflorescence has a panicle-like appearance, but is actually a raceme, typically 10 to 12 m in height. The flowers are aromatic, bell-shaped pendulums that are greenish or yellowish white (Cerón 1994; Figure 1). It is hypothesized that the flowers of *Furcraea* species are pollinated by insects (Rocha *et al.* 2006), however, little is known about this due to the low rates of flower visits (Eguiarte *et al.* 2000). Hummingbirds such as *Colibri coruscans* and *Patagona gigas* have been observed to feed on the flowers in the morning in the Ecuadorian Andes (S. de la Torre pers. comm.).

Ethnobotany and productive initiatives. Information was compiled from two sources: 1. Ethnobotanical literature and herbaria specimens documented in the Encyclopedia of Useful Plants of Ecuador (de la Torre *et al*. 2008). The encyclopedia draws from a collation of ethnobotanical research that has been carried out in Ecuador since the 18th century in at least 100 communities and 14 ethnic groups, including the Kichwa and mestizo communities of the Andes (de la

Figure 1. *Agave americana* and *Furcraea andina* in the Ecuadorian Andes. A. Flowering rosettes of *Agave americana* in Andean dry vegetation. B. Flowers of *A. americana*. C. Flowering rosettes of *Furcraea andina* in Andean dry vegetation. D. Flowers of *F. andina*.

Torre *et al.* 2008). This body of knowledge has been updated with the most recent publications and unpublished documents containing information on the uses of Andean Agaveae. 2. Semi-structured interviews to stakeholders of productive chains of the species studied. Interviews were conducted in June and July of 2016 across the Ecuadorian Andes (Table 1) and included a common set of open-ended ethnobotanical questions. A network of informants was created starting with representatives from governmental agencies, non-governmental organizations, and the academic sector involved in the promotion of Agaveae-based initiatives, who were asked about productive initiatives they were aware of. These informants identified centers of production and use of Agaveae in the northern, central and southern sub-regions of the Ecuadorian Andes, and constituted 19 % of the total number of interviews (n = 37). Eighty one percent of interviewees were producers from these production centers. Of those interviewed, 65 % were men and 37 % were women (n = 37); 57 % were indigenous people (Kichwa of the Andes), and 43 % were mestizos.

A database of the uses of each species was created. For *A. americana* we compiled two datasets: 1) uses of the plant, and; 2) uses of the sap, known as *mishki*. This distinction was made due to the diversity of *mishki*-specific applications. Each record of use in the database consisted

Table 1. Number of interviews completed to stakeholders of the productive chains of *Furcraea andina* and *Agave americana* in the Ecuadorian Andes and number of use records obtained from interviews and literature per each species by sub-region, province and ethnic group. For *A. americana,* a distinction is made between the use records of the plant and those of its sap (known as *mishki*). I: number of use records from interviews, L: number of use records from literature.

Subregion	Ethnic group*	Province	Interviews	*F. andina*		*A. americana*		*Mishki*		Total
				I	L	I	L	I	L	
Northern	Cayambis	Carchi	3	6		15		7		28
	Caranquis	Imbabura	2	8	14	4	14	5	10	55
	Kitu-kara	Pichincha	16	23	6	57	5	95	17	203
Central	Panzaleos	Cotopaxi	1	2	21	11	26	6	18	84
	Salasakas	Tungurahua	5	3	2	19	5	9	2	40
	Puruhaes	Chimborazo	2	8	12	13	15	4	6	58
	Chibuleos Warankas	Bolívar	1	4	3	4	2		1	14
Southern	Cañaris	Cañar	1	4	7	8	24	6	7	56
	Saraguro	Azuay	3	3	2	27	24	15	26	97
		Loja	3	1		13	5	15	8	42
Total			**37**	**62**	**67**	**171**	**120**	**162**	**95**	**677****

*The Andean region is inhabited by mestizos and indigenous people of the Kichwa of the Andes ethnic group, which is divided into 12 subgroups (de la Torre & Balslev 2008). Customs are shared among the Kichwa subgroups and the mestizos that inhabit each of these sub-regions.
**11 records of *F. andina* did not correspond to any province because they refer to potential uses that are not yet been practiced. There are 688 total use records in the database.

of: species, part of the plant used, description of use, location, and source of information. The uses were classified into nine categories in accordance with Cook (1995), with modifications (Appendix 1). A distinction was made by the interviewees in their answers between past uses (that are no longer practiced; these uses were reported by interviewees who recalled that they were practiced in the past), current uses (those still in practice), and potential uses (possible applications that are not currently practiced or are beginning to be tested).

We measured the following parameters of the two species studied: 1. Use diversity, consisting of the total number of uses (past, present, and potential) compiled for each one. 2. Use frequency, equal to the number of use records for each species in the database, that is, the total instances recorded throughout the study for each species. 3. Variation in their use patterns throughout the Ecuadorian Andes (use pattern understood as the distribution of use records in categories). This was analyzed with a chi square test. For the analysis, the Andean provinces were grouped into northern, central, and southern sub-regions; representing the three centers of use of Agaveae reported in the interviews. Possible bias due to the differences in the number of interviews performed in each sub-region was reduced as the database and analyses also included information from literature and herbarium specimens gathered throughout the history of ethnobotany research in Ecuador. Throughout the interviews, Agaveae-related productive initiatives in Ecuador were identified and located. Information about production sites, product processing, and access to the natural resource or raw material was compiled.

Results

Use diversity and use frequency were higher for *A. americana* than for *F. andina*. Fifty-two uses were recorded for the different parts of the *A. americana* plant plus 72 uses for the sap or *mishki* for a grand total of 124 uses of this species in 548 use records. Thirty-six distinct uses in 140 use records were recorded for *F. andina* (Tables 2 and 3, Figure 2). All of the Kichwa groups

Table 2. Number of uses and current usage status of *Furcraea andina* and *Agave americana* in the Ecuadorian Andes. For *A. americana,* a distinction is made between the uses of the plant and those of its sap (known as *mishki*). ND: Usage status not determined because the information was gathered from literature, in contrast with uses registered from interviews. *The sum of the current, past and potential uses is greater than the total uses because a particular use can be classified into "current" or "past" use in different locations.

Species	Total uses*	Current	Usage status (number of uses):		ND
			Past	Potential	
F. andina	36	9	10	6	21
A. americana/plant	52	21	17	7	37
A. americana/sap (*mishki*)	72	65	6	1	22
A. americana/Total	124	86	23	8	59

inhabiting the Andean provinces utilize and grow the species studied. The use of *F. andina* is less diverse and widespread in the southern Andes than in the northern and central Andes; however, we found no significant differences in the number of records by use category between these sub-regions. While no significant differences as regards to the plant of *A. americana* were found either, we did find differences in the use patterns of *mishki*. Significant differences were found in the number of records per use category between the northern, central, and southern Andean sub-regions ($\chi^2_{10} = 23.98$ $p = 0.0076$). Previously undocumented common names for both species were recorded (Table 4).

Ethnobotany of Furcraea andina. Its uses were included into eight categories (Table 3). Materials was the use category with the highest diversity of uses and number of use records. Within

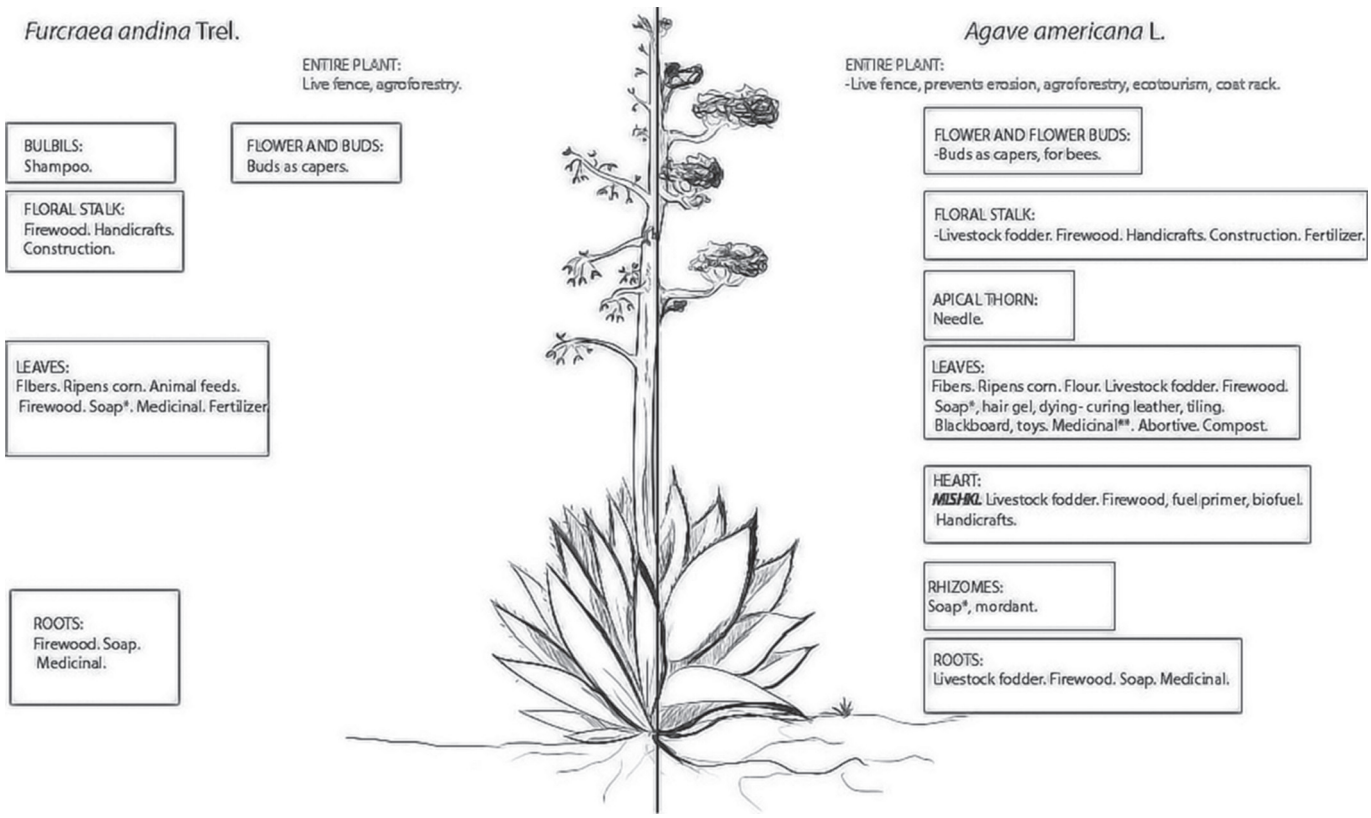

Figure 2. Comparison of the uses of the parts of the plant of *A. americana* and *F. andina*. For a description of uses see table 3. *Soap and shampoo. **Medicinal for organic and spiritual diseases. Elaborated by: Nicolás Santibañez and Lucía de la Torre.

Table 3. Summary of uses of *Furcraea. andina, Agave americana* ans its sap (*mishki*) by category in the Ecuadorian Andes. **Jora*, a type of corn used to make *chicha* (a fermented drink).

Category	*Furcraea andina*	*Agave americana*	*Mishki*
Food Additives	Leaves to ripen *jora**	Leaves to ripen *jora**	Used as a leavening
Food	Flower buds consumed as capers	Flower buds consumed as capers, leaves to make flour	Thirst quencher, sweetener, fortifier. To prepare syrup, panela, vinegar, ice cream, bread, tortillas, barbecues; a bran is obtained from scraping the heart
Animal Food	Leaves to prepare animal feeds	Leaves, floral stalk, heart and roots as livestock fodder	*Mihski* and bagasse for pigs, dogs, poultry
Apiarian		Melliferous flower	
Fuel	Floral stalk, leaves and roots used as firewood	Floral stalk, heart, leaves and roots used as firewood; heart as fuel primer, biofuel	
Materials	Floral stalk and leaf fibers used to make handicrafts, in construction (as beams and rope), fibers to make mattresses, scourers and to tie up crops; for paper, boards, linings, packaging and as substitute for fiberglass; floral stalk used as a harvesting stick; bulbils, fibers and roots used as shampoo; leaves and roots used as laundry soap and to wash calves	Floral stalk, heart and leaf fibers used to make handicrafts; floral stalk and fibers for construction (as beams and rope); leaf apical thorn as needle and thread; fibers for scourers, shampoo to prevent hair loss and as laundry soap; leaves as hair gel, for dying and curing leather; roots and rhizome as shampoo and laundry soap, rhizome as a mordant; leaves as tiling, blackboard and toys; plant as a coat rack	
Medicinal	Leaves to treat liver inflammation and scabies; roots to treat hematomas, wounds, ulcers and colds	Leaves to treat headache, broken bones, rheumatism, to get rid of parasites and as anesthetic; root to treat syphilis	To relieve pain of: rheumatism, bones, muscles, throat and heart; to treat osteoporosis, facial paralysis, kidney conditions, renal insufficiency; gastrointestinal and hepatic conditions, constipation; respiratory system conditions, cold, flu, coughs,"pasados de frío"; diabetes, obesity, high triglycerides and cholesterol; birth and postpartum conditions, prostate conditions, vaginal bleeding, hemorrhoids, skin conditions, pimples; cancer. For gut flora regeneration
Environmental	Plant as a live fence in agroforestry; leaves used as fertilizer	Plant as a live fence and to prevent erosion in agroforestry, ecotourism; floral stalk as fertilizer; leaves as compost	Decomposition of organic waste; bagasse as fertilizer, fungal control in crops and insect repellent
Social	*Capers* used in traditional dishes prepared in Carnival; fibers to make ceremonial cloaks	Leaves as abortive; leaves and root for curing illnesses of the soul; *capers* used in traditional dishes prepared in Carnival	*Mishki* is a reason for festivals and beliefs; it is used to prepare alcoholic beverages such as *guarango, chicha, curado, pingolito,* liquor, that are consumed in festivities and *mingas*; *mishki*, *guarango* and liquor as aphrodisiacs, fertility and invigorating agents; *mishki* for invigorating baths; *guarango* as a barter item

this category, the most common use is that of its leaf fibers in the production of handicrafts (*e.g.*, bags, hats and footwear. Figure 3) and ropes used in house construction, to tie up livestock or tie crops (27 % of records, n = 140). The practice of cultivating this species as a live fence or boundary marking is found across the region studied, although, according to interviewees, to a lesser extent than in the past and than *A. americana*. This use does not preclude the plant from being utilized for other purposes like the harvest of its leaves for fibers.

More of the uses of *F. andina* were reported as "past" (28 %, n = 36) than "current" (26 %) (Table 2). According to the users interviewed, the fibers from the leaves are used less and less

Table 4. Common names for *Furcraea andina* and *Agave americana* in the Ecuadorian Andes, compiled from literature and interviews to users. Newly registered names in **bold**. ND: No Data.

Species	Literature	This study
F. andina	Cabuya, cabuya blanca, cabuyo blanco, penco blanco (Spanish) (de la Torre *et al.* 2008)	**Chirpe** (Kichwa), cabuya, cabuya blanca, **cabuya hembra, maguey blanco, fique, penco verde** (Spanish)
A. americana	Mishki, tsawar mishki, yana chawar, yana tsawar (Kichwa) cabuya, cabuya azul, cabuya negra, cabuyo negro, chahuar, maguey, México, penca, penco, penco negro, sábila dulce (Spanish) (de la Torre *et al.* 2008)	Chahuar, chawar o tsawar (Kichwa), **cabuyo**, cabuyo negro, penco, **penco de cabuya**, penco negro, **penco azul,** maguey, México (Spanish)

Figure 3. Espadrilles made with the fiber of *Furcraea andina.*

to make handicrafts and tie up crops such as tomato and cucumber. The fiber's use to tie up mattresses stuffed with kapok (*Ceiba pentandra*) cotton dates back more than 50 years. Likewise, the plant's use as shampoo, laundry soap, and as a treatment for scabies is only remembered but no longer used by the interviewees. Seven potential uses were recorded. These included new applications of the fiber, such as the production of paper (*e.g.,* money, absorbent and artisanal paper), boards or linings, as a substitute for fiberglass, or the use of leaves to make fertilizer or a balanced feed for livestock. There is currently no initiative planning to test these potential uses in the near future.

Ethnobotany of Agave americana*.* Plant uses were included into nine categories (Table 3). The category with more diversity of uses and records was *Materials*. Representative uses include: the plant heart in handicrafts, such as chairs or drums (6 % of records, n = 291), the floral stalk in construction and the leaf fibers for handicrafts, such as bags and hats, ropes to tie up livestock, roofs and mudbrick walls made out of *sigse* (*Cortadeira nitida*) and floral stalks (5 % of records for each one). Houses with this type of walls were built 50 years ago in the highlands of the Northern Andes and would last up to 15 years. *Agave americana* is cultivated throughout this region as a live fence to delimit land for grazing and farming (Figure 4). This is the use of the plant with most records (30 %, n = 291), this practice remains current and, like *F. andina*, does not exclude its other uses. The use of the leaves as livestock feed is one of the primary feedstocks in the central Andes. One agave plant can provide weekly fodder to up to four cows. The most common use as food of *A. americana,* other than *mishki*, are its flower buds, known as capers.

Figure 4. Live fence of *Agave americana* delimiting crop lands in Salasaka (Central Andes of Ecuador).

This use was also reported for *F. andina*. While not related to the traditional caper, *Capparis spinosa*, used in Mediterranean cuisine, the Agaveae *caper* has a similar appearance and flavor after it is pickled in vinegar, lemon or *chicha*. *Capers* are a traditional specialty during Carnival in the city of Guaranda, and thus included in the *Social* use category as well.

We recorded 17 past uses for the plant (33 % of the total uses, n = 52) while 21 uses remain current (40 %; Table 2). The leaf fibers and plant parts that were used as shampoo, soap, dye, toys or blackboards have been almost totally replaced by synthetic products. Seven potential uses are part of the initiatives that are starting to emerge. These include the use of the leaves to produce flour for human consumption, compost and food for livestock, canned flower buds, shampoo made with the root at an industrial level, the whole plant for soil restoration in agroforestry systems and as biofuel.

Ethnobotany of mishki. Mishki means "sweet" in Kichwa and, as noted, is the name given to the sap that is obtained by exudation from the heart of the agave plant. It is obtained through common practices throughout the Ecuadorian Andes (Figure 5). Producers identify the maturity of the agave plant; as it gets larger, the heart thickens relative to the rest of the plant, the leaves broaden, lie flat, snap when crushed with the fingers, become whitish and their base yellowish, and the shoot shrinks and becomes thinner. Three smaller, narrower leaves with a curved apical spine grow around the shoot. The spine is known as *pico de loro* (parrot's beak) or *pico de gorrión* (sparrow's beak). July to September is the preferred time for harvest given the lack of rain that would otherwise damage the *mishki*. This is also when *mishki* is most in-demand owing to a lack of water from natural sources. Users recognize and cultivate variants of *A. americana* that are more suitable for harvesting sap, such as those with a higher concentration of sugar and smaller or no thorns on the leaves.

Uses were included in six categories (Table 3). The use category with the highest number of uses and records is *Medicinal* (49 % of records, n = 257 and 35 distinct applications). In the Northern Andes, 28 medicinal uses were reported and 15 are exclusive to this region. These vary from the treatment of acne to cancer. In the South, *mishki* is associated with the treatment of kidney diseases. Consumption to treat conditions of the musculoskeletal, respiratory and digestive systems is practiced throughout the whole country. In some places, the same medicinal properties are reported for the syrup and liquor made from this exudate.

The most common edible uses of *mishki* are as a sweetener, thirst quencher, and as an invigorating beverage. Among the indigenous communities in the Andes, *mishki* was the only sweetener available before the arrival and cultivation of sugar cane (*Saccharum officinale*). Tra-

Figure 5. Method of "cutting" the agave's heart by a lateral incision, and a rock used to block the hole at the agave's heart. These practices are characteristic of the Ecuadorian Andes.

Table 5. *Agave americana* (A) *and Furcraea andina* (F) by-products marketed in Ecuador and number of current productive initiatives.

Product	Initiatives number
Mishki (A)	35
Syrup (A)	13
Guarango (A)	7
Liquor (A)	8
Handicrafts with fibers (A, F)	6
Barley rice with *mishki* (A)	5
Handicrafts of floral stalk and plant heart (A, F)	3
Gourmet products with syrup (A)	2
Pickled capers (A, F)	1
Fibers (F)	1
Shampoo (A)	1
Medicinal ointment (A)	1
Wine (A)	1

ditional beverages such as *coladas* (thick beverages) from varieties of corn, *Cucurbita maxima, Curcubita pepo, Oxalis tuberosa,* were prepared with this sweetener. New proposals for *mishki* and its syrup include gourmet products like sauces and marmalades.

The Social use category includes the consumption of *guarango* (fermented *mishki*), a liquor (distilled *guarango*), and to a lesser extent, drinks made of *guarango* and fruit, known as *curado* or *pingolito*, during parties and *mingas* (communitary work). The production and consumption of *guarango* and liquor is higher among the Cayambis in the north and Cañaris and Saraguros in the south.

Although the use of *mishki* as Animal food, specifically for pigs, is present in the entire Andes, it is more common in the south. In some areas this is the only application of *mishki*. Most of the uses for *mishki* are still current. Six were recorded as "past" uses, which are applications that have disappeared in some areas but remain alive in others (*e.g.*, nutritious food for women after childbirth, for longevity and vitality for aged persons and as a substitute for water in arid regions). The only use that has disappeared throughout the entire country is the consumption of the dried and toasted bran that is obtained by scraping the orifice of the plant heart to obtain the *mishki*. This food was considered to be extremely nutritious and was consumed as an alternative when the crops were damaged due to frost in the province of Cotopaxi. Thus, it was vital for the survival of the people of the region. Only one potential use of *mishki* was documented: bottled and pasteurized *mishki*. It is expected to be sold at a national level and this initiative has already begun to be implemented in Salasaka.

Productive Initiatives. Fifty-three productive initiatives were identified with Agaveae in the Ecuadorian Andes (Figure 6). More startups have been developed in communities in the northern (26) and southern (17) sub-regions rather than in the central (10) sub-regions. Most of them (92

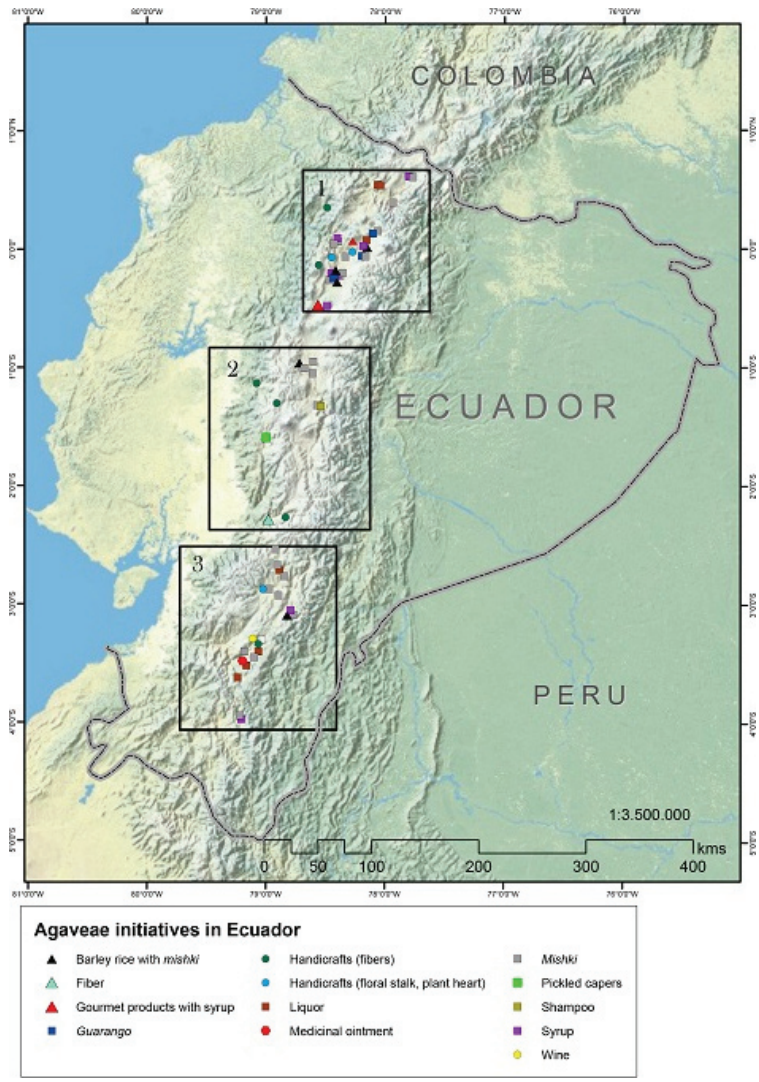

Figure 6. Location of productive initiatives with Agaveae in Ecuador. 1: Northern, 2: central and 3: southern subregions of the Andes.

%) include *A. americana,* and *mishki.* Thirteen products are commercialized in Ecuador. Those most frequently marketed are *mishki* and its by-products (*e.g.*, barley rice with *mishki*, syrup and liquor). The production of fiber and handicrafts is considerably lower and involves fewer actors (Table 5). Nine producers considered that there is a scarcity of *A. americana* plants due to: 1- low rates of replanting of harvested plants; 2- the construction of roads that has destroyed this plant's habitats; and, 3- the loss of traditional knowledge and uses of the species. Last year, the production of packed capers decreased six fold during the carnival in Guaranda due to scarcity. This has become more noticeable in the last years in areas where liquor is produced in the Southern Andes.

Discussion

Cultural importance of Andean Agaveae. *Agave americana* and *Furcraea andina* can be considered keystone species for the development of Andean indigenous and mestizo cultures of Ecuador. These species played an important role as a source of materials in the past. *A. americana* played and continues to play a fundamental role in people's diets, livestock breeding, as a medicine and in ceremonies. For example, mishki was consumed as a substitute for water to quench thirst during dry seasons or in dry areas, it was the main sweetener before the arrival of sugar cane and the bran obtained from scraping the heart was consumed as an alternative food

source when frost destroyed crops. The fermented mishki or *guarango* is an indispensable drink during celebrations such as the Inti Raymi (grain harvesting season during the summer solstice) for Kichwa groups. The flower buds or capers are consumed as a traditional specialty during Carnival in the city of Guaranda, and are also consumed during Easter in rural communities (Cobo 2014). This species promotes cultural cohesion in the Ecuadorian Andes.

Agave americana higher use diversity and versatility lies in its *mishki*-producing heart. In turn, usefulness of more versatile species is generally more widespread among people than that of less versatile ones (Tardío & Pardo-de-Santayana 2008, Macía *et al.* 2011). Furthermore, *A. americana* is one of the plants most cultivated as a live fence in the Andes (Carlson & Añazco 1990), which would contribute to its high number of medicinal uses that it has. Due to its availability, there would be more opportunities to experiment with new medicinal applications for this species (Stepp & Moerman 2001, Bjorå *et al.* 2015). *F. andina* is also a versatile plant, although to a lesser extent because its "heart" is considered too narrow to obtain *mishki.* It is cultivated less (de la Torre *et al.* in prep.) and, therefore, its availability is reduced. *Agave americana* meets all the criteria to be considered a cultural keystone species given its high rating according to an index based on six criteria proposed by Garibaldi & Turner (2004) and outlined below:

1. Its use diversity and intensity of use are high (124 uses in nine categories and 548 use records), compared to other versatile and widely used plants in Ecuador, identified using criteria similar to this study (*e.g.*, *Juglans neotropica, Oenocarpus bataua, Verbena litoralis* with 97, 34, 70 uses in 5, 8, 5 use categories and 122, 178, 176 use records, respectively; de la Torre *et al.* 2008, 2013) or to the number of uses reported for agaves in Mexico (44 - 100 uses; Colunga-GarcíaMarín *et al.* 2017, Granados 1993, respectively) determined using different discrimination criterion.
2. It is well represented in both Kichwa and Spanish, there are common names for the species (Table 4), varieties (de la Torre *et. al*. in prep.), plant parts (Appendix 2), and products (Appendix 3), and is also present in the toponymy of the region (*e.g.*, *Chaguarpamba, Chaguartola*, which mean "land and hill of *A. americana*," respectively) (Cobo 2016).
3. As previously stated, it plays an important ceremonial role including fertility rituals in which *mishki* is given as an offering to the land (Cobo 2016).
4. Its uses, for the most part, are still practiced throughout the Andes.
5. It has a unique status in the culture and, mainly due to its *mishki*, it is not easily replaced with other available species.
6. Several items are produced from it which are increasingly sold in the country.

Furcraea andina was fundamental as a source of fibers used in hunting, cultivation, clothing, footwear, household goods and construction. It could be considered to have been a keystone species, particularly in the past before there were synthetic materials available to replace its fibers. The fibers of *A. americana* were used for similar purposes but *F. andina* fibers were preferred as they are easier to obtain from the leaf, to dye, and to weave owing to their softer and more flexible nature, furthermore, they can be harvested in less time (M. Presentación and Z. Guamán pers. comm.). The dependency of cultural keystone species on context (temporal, spatial and social) has been addressed by the creators of this concept (Cristancho & Vining 2004, Garibaldi & Turner 2004). *F andina*, could have played a key role within a restricted time period in the past for Andean cultures in Ecuador.

The reported cultural value of *A. americana* and *F. andina* can contribute to the conservation of its associated culture and could enhance initiatives for Andean ecosystem conservation and restoration with these species.

Agave americana*, an introduced species in Ecuador?* The cultural importance of *A. americana* throughout the Ecuadorian Andes supports the hypotheses that it arrived long ago. The significant differences found in the use patterns of *mishki* between the northern, central and southern sub-regions of the Ecuadorian Andes, in addition to evincing the versatility of *A. americana*, could indicate that it has been subject to an extended period of use. Plant use patterns in a given place depend on interrelated natural, social, cultural and historical factors. These factors include species abundance, varietal characteristics, plant diversity of the surrounding ecosystem (allowing ac-

Table 6. Uses of *Agave americana* in Andean countries aside from Ecuador. For Venezuela information of *Agave cocui* was included. Sources: Venezuela: Tirado 2002, Savedra *et al.* 2006; Colombia: Carbonó-Delahoz & Dib-Diazgranados 2013; Perú: Pardo-Briseño 2005, Venero-González 2006, Agronetworks 2016; Bolivia: Peña 1976, Torrico 1994, Hurtado 2007.

Use category	Venezuela	Colombia	Peru	Bolivia
Food	Sap. Flowers are mixed with chili pepper and are prepared in stews or pickles	Sap.	Sap consumed raw or used to prepare panela, syrup, fermented beverages	
Animal Food			Tender floral stalk to feed cattle	
Fuel			Dried leaves as firewood	
Materials			Leaves as a source offibers. Leaves used as canvas to write love letters with the thorns	Floral stalk to build ladders. Leaf fibers to make ropes and sacks
Social	Liquor from the sap of *Agave cocui* is prepared since prehispanic times and consumed on rituals and social events		Liquor is consumed on social events	
Medicinal		To treat bronquitis, uterine pain, dysenteria	Tender floral stalk expels *Fasciola hepatica* from cattle	
Environmental			To protect soil. Plant as a live fence to stabilize platforms and to prevent erosion	Plant as a live fence, barrier to prevent fire dispersion and erosion, and ornamental

cess to substitute species), cultural preferences, the technology available to process that resource, market access, time of arrival, *i.e.*, time for experimentation with the plant, and contact with other human groups resulting in the transfer and loss of knowledge (Campos & Ehringhaus 2003, Byg & Balslev 2004, Byg *et al.* 2007). Thus the variation in use patterns found imply the extended interaction of these factors. The archeological evidence of vessels suggesting their use for storing *mishki* and its by-products (Proyecto Chasqui 2016, Mindalae Museum pers. obs. of L. de la Torre) and testimonials of chroniclers (De Velasco 1977, De la Vega 2004) also support this hypothesis.

Despite its continuous distribution in America (eMonocot 2017, GBIF 2017, Tropicos 2017), and its proven capacity for natural propagation (BioNET-EAFRINET 2001, Hodgkiss 2017, *A. americana* is considered an introduced species in South America (Peña 1976, Tirado 2002, Venero-González 2006, Bernal *et al.* 2015), although there are no studies specifying how and when it was introduced. There are native species of *Agave* in other Andean countries: *Agave cocui* in Venezuela and Colombia, *A. cudinamarcensis, A. boldinghiana, A. pax* and *A. wallisii* in Colombia and *A. cordillerensis* in Peru (Lodé & Pino 2008, Hoschstatter 2015, Hodgkiss 2017, Giraldo-Cañas 2017). It is plausible that other native species of *Agave* or at least native varieties of *A. americana* exist in Ecuador. It would be desirable to perform genetic analyses that clarify its arrival to South America, and, particularly, to Ecuador.

Besides the contribution to the knowledge of the origin and distribution of agaves that these investigations would represent, *A. americana* would benefit from political decisions that prioritize native taxa over introduced ones, e.g. reforestation incentives, the declaration of its products and processing cultural patrimony, and the promotion of productive initiatives.

Use of Agave *in the equatorial Andes compared to Mexico and other Andean countries*. The cultural importance of *A. americana* in the equatorial Andes is comparable to that found in *Agave* spp. in Mexico, but not to other Andean countries where its uses are less diverse, less extended and sporadic (see Tables 6 and 7 for citations and a comparison of uses). In Mexico, there are 186 *taxa* within the *Agave* genus that grow in 75 % of the territory; more than 100 species are useful and have played a fundamental part of the survival of communities in arid and semiarid areas (García-Mendoza 2007, García-Herrera *et al.* 2010, Colunga-GarcíaMarín *et al.* 2017). At least 12 species are domesticated (Colunga-GarcíaMarín *et al.* 2017). Terms for these species and for each part of the plant can only be found in some languages in Mexico and the Kichwa of the Ecuadorian Andes (Table 4, Appendix 2).

Table 7. Comparison of uses of sap producing *Agave* spp. in the Ecuadorian Andes and Mexico. Source: This study, Pardo-Briceño 2005, García-Mendoza 2007, García-Herrera *et al*. 2010, Parra 2016, Colunga-GarcíaMarín *et al*. 2017. **Jora*, a type of corn used to make *chicha* (a fermented drink).

Use category	Similar uses	Particular uses to Mexico	Particular uses to Ecuador
Food and Food Additives	*Mishki* as a sweetener, thirst quencher, invigorating, to make syrup, vinegar, fermented beverages, liquor, flavoring for compot, stews, tamales, bread, tortillas, barbecues; as a leavening, flower buds consumed in stews	Leaf cuticule to wrap food, floral stalk, plant heart and base of the leaves are consumed boiled or grilled. Sap to soften meat. Perianth of the flowers to make tortillas. Fresh capsules of the fruit are consumed in stews and sweets	Flower buds consumed as pickles, with *chicha* or syrup. Leaves to ripen *jora**. A bran is obtained from scraping the heart
Vertebrate Food	To prepare animal feeds for poultry, cattle and pigs. Leaves as food for cattle, goats and pigs	Flowers and floral stalk to feed domestic animals	*Mishki* to feed pigs, poultry and dogs. It is given to cows to increase milk production. Roots as fodder for domestic animals
Invertebrate Food/Apiarian		Food for edible insects such as larvae from ants (*Liometopun apiculatum* and *Liometpum occidentale*) and caterpillars (*Acentrocneme hesperiaris* and *Hypopta agavis*)	Melliferous flower.
Fuel	Leaves, heart and floral stalk as firewood		Roots as firewood. Heart as fuel primer
Materials: fabrics and clothing	Threads, ropes and fabrics to manufacture sacks, bags, girdle, blankets, cloths, rugs, sandals, belts, matting, hats, fishing nets, nets for transport and load, to tie animals	Leaf fibers to manufacture hammocs, tortilleros, backpacks, mecapals, shrouds, *ayates*, strings for musical instruments	To tie mattresses made of kapok cotton. Tannins to tan leather, dye for blankets, to whiten wool
Materials: construction	Floral stalks as beams, poles, columns, pens, fence posts, roofs. Leaves as tiles	Canals to collect rain water, tray to mix construction materials, thermoplastic or thermophilic resins	Fibers to make ropes to tie beams in roofs, and mudbrick walls made of *Cortadeira nitida* and floral stalks
Materials: household			
	Laundry soap, shampoo, needle with thread, scourers, pots, chairs, furniture	Leaf, leaf fibers, floral stalks for brushes and brooms, baskets, nails, trays, barbecue materials, pot lids, sticks for the extraction of edible larvae, farm tools. Floral stalk and flowers as hunting bait	Soap and scourer to wash calves, chicken nests, plant as a coat rack
Materials: other	Fibers for decoration, to make toys for children. Handicrafts made with the floral stalk	Christmas decorations, body adornments, rattles, headgear for women	Blackboards, musical instruments made with the plant heart and flora stalk
Medicinal	To treat bruises and wounds, lack of mobility in the limbs, anemia, as an invigorating to improve the immune system, for women recovery after a sickness or labor, promotes breast milk production. Veterinary use	To treat scurvy	To treat all type of conditions related to bones and joints, rheumatism and joint pain, facial paralysis. Analgesic, relieves all type of pain. Disinfectant, antiseptic. To treat kidney and prostate conditions, digestive and respiratory system conditions, cold, sinusitis, bronchitis, cancer, diabetes, hemorrhoids, varicose veins, acne, insomnia
Social	*Guarango* or *pulque* is consumed in parties and communal work. It is aphrodisiac and a fertility agent. Liquor is consumed on social events	*Magueyes mezcaleros* used to make mezcal, tequila, bacanora, sisal. Entire plant and floral stalks have ceremonial uses	*Mishki* to treat frights and as a blood purifier. *Mishki* is a reason for festivals
Environmental: forestry, agriculture and livestock.	Restoration of degraded areas, recovery of native flora and fauna, delimit land, create terraces, protecting fences, to prevent erosion, maintain humidity and as an organic fertilizer. Part of agroforestry systems		Is cultivated on the top of adobe walls. Chopped floral stalk as a soil fertilizer
Environmental: ornamental	Gardening in public parks and houses	Christmas decoration, body decoration, rattles, headgear for women	

There are similarities and differences in the uses given in Ecuador and Mexico (Table 7), likewise in the *mishki*-obtaining procedures and by-product preparation (Appendix 3). It is possible that there was an exchange of knowledge between Mexico and Ecuador. This could have occurred either if the plant had arrived by its own means or was introduced by humans due to its utility. This exchange could have happened at a number of different times:

1. With the arrival of the first settlers to Ecuador from the north during the preceramic period (Almeida-Reyes 2000). However, uncertainty remains as regards why it is not used with similar intensity in Venezuela and Colombia where this species also grows (Table 6).
2. Through seaways, mainly during the peak stage of the Manteña culture in the Coast of Ecuador (800-1530 AD), yet it could have also happened in various previous stages (Jiménez & Quezada-Domínguez 2014). It is known that the inhabitants of the Ecuadorian coasts, such as the Manteños, were excellent sailors and it is assumed that they maintained commercial relations, based on the *Spondylus* shell, with communities from the west of Mexico (Anawalt 1992, Marcos 2005, Carter 2008). This shell would have been the main item of commerce with the Andes (Paulsen 1974). Similarities that have been identified in weaving techniques and textile designs between the Ecuadorian Coast and the west of Mexico support this hypothesis (Anawalt 1992). This would explain why the use of *A. americana* in Ecuador is more diverse and ingrained than in other Andean countries: the knowledge was passed on to the Andes where the species was cultivated or grew in the wild. The spreading of knowledge to other Andean countries could have occurred following the arrival of the Incas. This option also explains the particularities of use between Ecuador and Mexico.
3. The exchange occurred later, during the first stages of the Colonial period, through Spaniards that traveled between Mexico, other Central American countries and Ecuador, and brought indigenous people from those places (Newson 1995, Terán 1973) were *A. americana* is a native species (Gentry 1982).

The comparison of *Agave* uses between Ecuador and México, highlights the high use diversity and cultural importance of the genus in Ecuador, even though that there is only one species available. It has been reported that in areas of decreased species diversity, a similar variety of uses is distributed among the fewer species available, resulting in higher use intensity per species (FAO 1995b).

Future perspectives of the Andean Agaveae. *Furcraea andina* has traditionally been a primary source of fiber for indigenous communities in Ecuador, however this use is rapidly disappearing due to the increased availability of lower priced, synthetic products. Market access is one of the main factors that affect plant use patterns resulting in a decrease in the use of vegetable products by local communities (Ladio & Lozada 2001, Byg *et al.* 2007).

In Ecuador, the area used for cultivation for Agaveae-fiber production has decreased from around 3,000 hectares in 1980 (FAO 1995a) to around 1,000 hectares in 2013 (Ayora & Quito 2013). As recently as 2008, Ecuador exported 17.39 T of rope and riggings made from Agaveae fiber (Yépez *et al.* 2009), while in 2013, Ecuador went from exporting Agaveae fiber to importing it (T. Zamora pers. comm.). Fiber production from *F. andina* and other fiber by-products is limited to a few initiatives, generally organized groups of indigenous women that produce handicrafts of unique beauty and quality but with limited markets. Furthermore, currently no initiative is being tested for the potential applications of *F. andina* for fiber (*e.g.*, production of artisanal, absorbent or money paper). These uses could benefit the country as it is a net importer of fiber (Yépez *et al.* 2009, Viveros 2017)).

The number of initiatives with *A. americana* has increased in recent years due to a number of reasons. These include: 1- the growth of organizations that have supported the development of productive alternatives in rural indigenous communities; 2- the increase in consumption of *mishki* and its by-products owing to their nutritional and medicinal qualities emphasized by the media (AGN 2016, Agrovida 2016, Tungurahua 2016); the production and consumption of liquor has also increased as a result of tasting events being held (Alvarado 2017); and 3- an increasing tendency in consumption of natural products, especially sweeteners that are healthier than those obtained from sugar cane (Tandel 2011, Mellado-Mojica & López 2015). Coinci-

dentally in areas with more *mishki*-based initiatives, in the Northern and Southern Andes, there is a major perception of scarcity of *A. americana.* To avoid overexploitation and local extinctions, it is necessary to replace the harvested plants and to reforest marginally arid areas with this species. As 49,000 km^2 or up to 17 % of Ecuador's surface is suitable for its cultivation, the prospects for increased production of *A. americana* are positive (de la Torre *et al.* in prep).

To satisfy the increasing demand of tequila and mezcal, natural populations of Mexican agaves have been overexploited (Colunga-GarcíaMarín *et al.* 2017), which together with the degradation of natural habitats, has threatened 48 species of agaves (Franco-Martínez 1995). In 2016, more than 115,000 hectares of *Agave tequilana* were cultivated throughout Mexico (SAGARPA 2016) and 273.3 million liters of tequila were produced (Consejo Regulador del Tequila 2017). The monocrop of clones of *Agave tequilana* has caused a reduction in genetic diversity and contributed to the destruction of natural habitats (Colunga-GarcíaMarín *et al.* 2017). Thus, it is recommended that *A. americana* be cultivated from seeds and not only through offshoots, and in environment friendly systems such as agroforestry systems. Traditional practices of indigenous communities could be taken as a model.

To achieve the sustainability of productive initiatives with *A. americana*, the associated culture and history behind its by-products must be emphasized. Furthermore, Agaveae products come from plants that grow in arid areas, contribute to soil improvement, prevent erosion, regenerate ecosystems and mitigate climate change through carbon fixation (García-Herrera *et al.* 2010). Currently 13 products derived from Agaveae are commercialized in Ecuador, few compared to the diversity of uses recorded in this study. Information from this study can encourage the development of new products that help to improve the quality of life of agricultural communities in the Ecuadorian Andes.

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Appendix 1. Categories used to classify the Agaveae uses. Based in the proposal of Cook (1995) with modifications in de la Torre *et al.* 2008.

Use category	Definition
Food	Edible plant parts for humans, including those used to make beverages
Food additives	Additive agents and other additive ingredients used for processing food and beverages either to expedite processing or to improve palatability
Animal food	Forage and fodder for domestic or wild vertebrates that, generally, serve as a source of food for human beings
Invertebrate food	Plant parts eaten by invertebrates useful to humans such as ant larvae
Apiarian	Pollen, nectar or resins to bees for honey or propoleum production
Fuel	Plant parts used to produce petroleum substitutes, alcohols, combustion starters, firewood
Materials	Plant parts that are a source of raw material for construction of houses, fences or bridges, to craft objects, musical instruments, tools, weapons, and all kinds of utensils
Social	Plant parts used for cultural purposes that are not defined as food or medicines. This category includes hallucinogens, contraceptives and plants with ritual or religious significance. The cure of cultural or spiritual disorders such as "bad air" are also included
Medicinal	Plant parts used to cure, alleviate and prevent human illnesses, including plants for veterinary use
Environmental	Plants used to protect, improve, and fertilize the soil and against erosion, that provide shadow, that are used as fences or barriers, to control fires, decrease pollution, or are part of agroforestry systems. Plants that control crop pests and insect repellents. Ornamentals

Appendix 2. Glossary of terms of Agaveae plant parts in Ecuador and Mexico. Sources: Alemán 2016, Plan Junto 2016.

Ecuador	Mexico	Definition
Yute, jarcia	Ixtle (Nahuatl)	Agave leaf fibers
Chawarquero (Kichwa)	Quiote o calehual (Nahuatl)	Inflorescence of any Agaveae plant characterized by a large floral stalk and flowers in clusters or spikes
Alcaparra (Spanish), kirillo (Kichwa)	Gualumbos (Nahuatl), doni (Otomi)	Edible flower bud of some Agavea species
Polongo, congón o fondolongo	Mezontete, metzintetl (Nahuatl), ñä´mfr (Otomí)	Central part of the rosette known as the heart, core, head or pineapple
Tzawarpanga (Kichwa)	Pencas, ´ye´ta (Otomí)	Agave leaves
Cogollo (Spanish), tzawarkingu (Kichwa)	Cogollo (Spanish), meyolote (Nahuatl)	The meristem where the leaves of the plant originate
Tzawarzapi (Kichwa)	Nelhuayotl (Nahuatl), ´yu´ta (Otomí)	Agave roots
Higuilla	Mecuate (Nahuatl), t´y´ta (Otomí)	Agave offshoots or clones know as pups
Puya	Mehuitztl (Nahuatl), ´bimda (Otomí)	Terminal apical spine of the agave leaves
Patza (Kichwa)		Organic remains from scraping the orifice of the plant heart of the agave

Appendix 3. Comparison of methods to obtain *mishki* and products derived from the sap of *Agave* spp. in the Ecuadorian Andes and Mexico. Sources: This study, Alemán 2016, Consejo Regulador del Tequila 2017.

Ecuador	Mexico
Mishki, chaguarmishki	***Aguamiel, neutli***
• Method of "cutting" the agave: A lateral incision is made. One or more leaves are pulled away from the middle part of the agave to make a lateral opening at its center. Water is usually added and the hole is blocked with an agave leaf or with a rock. After 1-2 weeks the water is removed and the hole is scraped. From this point on, *mishki* can be produced for up to 45 days. • Generally the men "cut" the agave and the women, known as *mishkeras*, harvest the agave daily. • Tools: A metal spoon with a sharpened edge (*cuchareta*, *aspina, chiccinia*, *churo*) is used to scrape the plant heart while avoiding the opening to heal and promoting the plant to continue the exudation. A *mate* (container made with the fruit of *Crescentia cujete*) is used to collect the *mishki* or the inflorescence stalk of *sigse* (*Cortadeira nitida*), which is used like a straw to suck out the *mishki*.	• Method of "castrating" the agave: A central incision is made, with the opening at the top of the shoot. Water is added and the hole is blocked with an agave leaf. After 1-6 months, the water is removed and the hole is scraped. From this point on, *aguamiel* can be produced for up to six months. • Generally, the men, known as *tlachiqueros*, "castrate" and harvest the agave daily. • Tools: A metal spoon with a sharpened edge (*metzal*) is used to scrape the plant heart, while avoiding the opening to heal and promoting the plant to continue the exudation. An *acocote* (*Lagenaria siceraria*) is used as a pipette to extract the *aguamiel*.
***Guarango, guajango*, viejito o viejita**	**Pulque, *octli* o *tlachicotón***
The *mishki* is boiled until there is no longer foam. Once it has cooled down to a warm temperature it is added small quantity of *guarango* from previous days (known as seed) so that it ferments.	It is is made with raw *aguamiel*, which is added to the *pulque* from previous days (known as seed) so that it ferments.
Honey or syrup	**Honey or syrup of *Magueyes pulqueros***
The *mishki* is boiled in clay or stainless steel pots until it is concentrated into a syrup. There is a consensus that one liter of syrup is obtained from 10 liters of *mishki*.	
Agave liquor, miske	**Liquor of pulque**
Guarango or *pulque* is distilled. During or at the end of the process the resulting liquor is mixed with water so that the final alcohol content is 39 %.	
	Mezcal, tequila, bacanora, raicilla
Not produced	There are at least 14 species that produce these products, including *Agave americana* var. *oaxacensis*. Products are obtained through the baking of the whole or heart, which is then squeezed. The remaining liquid is fermented and distilled. The name tequila is a geographical indication for the liquor obtained through the described process from *A. tequiliana* Blue variety, from Jalisco and some municipalities of Guanajuato, Michoacán, Nayarit and Tamaulipas. Bacanora is a geographical indication for the liquor obtained from *A. angustifolia* from Sonora region. Raicilla is a liquor from *A. maximiliana, A. inaequidens* and *A. angustifolia* from some cities in Jalisco.