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Research

Nurturing forest memory: native bamboo as an assemblage of biocultural keystone species in the southern Andes

Annika J. Levaggi[1] *and José Tomás Ibarra*[1,2,3]

ABSTRACT. Presently, with the acceleration of climate change and rural land development, foraging spaces remain increasingly under threat. In Andean temperate forests of southern Chile, these challenges, coupled with ongoing legacies of colonization, threaten the biocultural memory of an assemblage of foundational understory species, the *Chusquea* spp. Both the commonly named species kila (*Chusquea quila*) and koliwe (*Chusquea culeou*) stand out for their ecological importance and, moreover, for their historical usage and significance among Mapuche and campesino communities. To better understand the biocultural importance of the *Chusquea* spp., we implemented a biocultural keystone species assessment among Mapuche and campesino communities. Moreover, drawing from community-based participatory frameworks, we collaborated with local foragers to synthesize recommendations for best management practices and develop guidelines to identify high-quality harvestable *Chusquea* spp. To conduct the biocultural keystone species assessment and synthesize management recommendations, we carried out participant observation, informal interviews, and snowball sampling, and conducted ethnographic interviews and fieldwork assessments with 16 expert foragers across the Mallolafken watershed in the La Araucanía region, southern Andes of Chile. Our results identified the *Chusquea* spp. as an assemblage of biocultural keystone species, with 62 household uses, critical contributions to food security, ceremonial significance, and cultural roles as a messenger, protector, and companion. Consultation with foragers also determined harvesting guidelines in accordance with use type based principally on variations in (1) color, (2) diameter, and (3) leaf abundance. While few foragers actively manage *Chusquea* spp. aside from using animal grazing to prune and control growth, some foragers shared techniques for reproducing stands. The lack of salient Traditional Ecological Knowledge related to *Chusquea* spp. management reflects their threatened biocultural memory. Future research coupled with community outreach regarding *Chusquea* spp. management is needed to support foraging practices and forest conservation efforts in the region.

Key Words: *biocultural memory; Chusquea culeou; Chusquea quila; forest management; Traditional Ecological Knowledge*

INTRODUCTION

In recognizing the interconnectedness of social and ecological systems, socio-ecology asks us not only to consider how social injustices have been historically entangled with ecological degradation, but also how processes of repair might similarly go hand in hand (Society for Ecological Restoration 2004, Artelle et al. 2019, Berkes 2021, Lucero et al. 2023). Among practices of repair, nurturing Traditional Ecological Knowledge (TEK) has gained traction as a promising pathway toward ecological regeneration and cultural revitalization (Berkes et al. 2000, Toledo 2002, Turner et al. 2011, Nelson 2014). TEK embraces not only a set of information but the accompanying practices and beliefs that are generationally honed and adaptive to ever-changing social-ecological contexts (Berkes et al. 2000, Toledo and Barrera-Bassols 2008). TEK encompasses the dynamic between a (1) "corpus" of situated biological knowledge (identification, habitat, distribution, seasonality, etc.) and (2) "praxis," or set of practices (tools, techniques, monitoring, management, etc.) which are embedded within a (3) cosmos, or the cultural context that outlines the use norms and greater worldviews that shape species associations and perceptions (Jacques-Coper et al. 2019). Biocultural memory refers to the process by which experiences, beyond just those of individuals, are gathered and passed down over generations to form a collective cognizance that helps communities adapt to variable social-ecological conditions (Nazarea 2006, Maffi and Dilts 2014). In this way, TEK has been considered a form of biocultural memory (Jacques-Coper et al. 2019). Both TEK and biocultural memory can play critical roles in increasing resilience in the wake of the present social-ecological crisis (Barthel et al. 2010, Gómez-Baggethun et al. 2013a, Turner 2014, Robinson et al. 2021, Ibarra et al. 2024a).

Certain species are particularly pertinent to nurturing biocultural memory. A species' importance can be reflected in its presence within cultural spheres of language, art, religion, technology, and so forth (Ibarra et al. 2012). Such species include charismatic megafauna like the grizzly bear (*Ursus arctos horribilis*), which takes center stage in ceremonies, pastimes, and stories among Indigenous communities along coastal British Columbia (Clark et al. 2021), and foraged food staples like pewen seeds (*Araucaria araucana*) for the Mapuche Pewenche people of the Andes (Herrmann 2005, Ibarra et al. 2022). In the land-based cultures of many Indigenous peoples, a species' significance is also extended in terms of its ecological roles, such as in water filtration or soil regeneration (Rozzi et al. 2008, Van Horn et al. 2021, Ojeda et al. 2022). For example, the Lakota revere buffalo (*Bison bison*) not only within cultural domains but also for their ecological contributions to Great Plains ecosystems (Knapp et al. 1999, Patel and Grey 2014). Notably, species that hold greater significance in both cultural and ecological domains may be denoted as

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biocultural keystone species (Ibarra et al. 2012). This term is in line with the natural sciences concept of "ecological keystone species", developed by Paine (1969) to distinguish species with an overwhelming influence over the well-being of whole ecosystems and the later metaphorization by the social sciences that coined "cultural keystone species" (CKS) to acknowledge species that profoundly shape social groups' well-being or worldviews (Cristancho and Vining 2004, Garibaldi and Turner 2004, Ellen 2006). Over the last decade, numerous research studies have used the biocultural keystone species framework to capture the entangled social and ecological importance of species like the Andean Condor (*Vultur gryphus*) within Aymara society, and the black ash (*Fraxinus nigra*) among Wabanaki tribes, as well as in the form of assemblages such as medicinal plants within mountain communities in the Southern Alps (Costanza et al. 2017, Jacques-Coper et al. 2019, Petelka et al. 2022).

Some studies have explored how changing social-ecological conditions can impact local livelihoods by reducing populations of biocultural keystone species (Costanza et al. 2017, Uprety et al. 2017) or eroding popular reverence for them (Jacques-Coper et al. 2019). Other studies have used the biocultural keystone species concept to identify critical species from a larger set of candidates (Tardío and Pardo-de-Santayana 2008, Thomas et al. 2009, Kazancı et al. 2023). Oftentimes, such work has become associated with flagging focal species to support conservation and restoration work (Garibaldi and Turner 2004, Garibaldi 2009, McKemey et al. 2020). Importantly, the biocultural keystone species concept has been critiqued for its essentializing tendencies that overlook the interactions within assemblages of multiple species (Cottee-Jones and Whittaker 2012, Ogden et al. 2013, Aisher and Damodaran 2016). Hence, in this study, we strive to understand not only how communities in the southern Andes use and manage native bamboo, but also how their lives have been duly shaped by the *Chusquea* spp. (Tsing 2015, Harraway 2016). Moreover, most biocultural keystone species assessments weigh their arguments in favor of either ecological or cultural contributions and often use qualitative approaches to describing cultural phenomena (Guerrero-Gatica and Achondo 2022). Here, we offer a model for how transdisciplinary collaborations coupled with a quantitative cultural assessment can offer new modes for conceptualizing biocultural keystone species.

In the southern Chilean Andes, the native bamboo species, the kila (*Chusquea quila*) and koliwe (*C. culeou*), represent a potential pathway to nurturing, both ecologically and culturally, some areas of Andean temperate ecosystems and the Indigenous Mapuche and campesino communities whose livelihoods are greatly associated with them. The kila and koliwe are the most common species within an assemblage of bamboo species found in south-central Chile (37-43º S) (Fig. 1). These *Chusquea* species are characterized largely by their dominance among the understories of temperate Andean forests, between the elevations of 200 and 1000 m (Rojas et al. 2011). As pioneer species, their prevalence is often considered an indicator of deforestation, forest degradation, or previous burning (Veblen 1982). However, their regenerative qualities have been found to play critical roles in enhancing soil stability, biodiversity conservation, and nutrient cycling (Altamirano et al. 2012, Caviedes and Ibarra 2017, Concha et al. 2023). The kila, known by its common name in mapudungun (Mapuche language) as the *kila* or *kilautre*, grows

Fig. 1. The *Chusquea quila* (left) and *Chusquea culeou* (right).



primarily between 200 and 700 m elevation and is distinguished by its branching form, which allows it to climb adjacent trees (Veblen 1982). The kila's ability to produce new branches allows it to grow in heavily shaded conditions and expand rapidly. Between 700 and 1000 m above sea level, the dominant bamboo species becomes the koliwe (colihue or coligüe) or, in mapudungun, the *coles* or *rëngi* (Veblen 1982, Ibarra et al. 2018). The koliwe is distinguished by its vertical growth form with stocks that form groupings up to 3 m in diameter (Veblen 1982). These bamboo species have been associated with 58 wildlife species (three reptiles, six amphibians, 20 mammals, and 29 birds), providing food resources, refuge, and nesting opportunities for them (Ibarra et al. 2018). Beyond their ecological role, these bamboo species have long since been embedded in the biocultural memory of the Mapuche communities belonging to Wallmapu (ancestral Mapuche territory). Historically, native bamboo was fashioned into spears and used to construct mazes in the successful defense of Wallmapu against Spanish colonization (González Cangas and González 2006). Both species hold ceremonial significance, and a number of studies have recorded their various uses from construction to artisan works, as well as for fodder and canned food supplies (González Cangas and González 2006, Barreau 2014, Whitman et al. 2014, Cordero et al. 2022). The *Chusquea quila*, in particular, has been found to have remarkably high nutritional value as animal forage (Venegas 2023).

Presently, native Andean temperate forests are facing increasing threats due to accelerations in climate change as well as ongoing histories of forestry expansion, intensive agricultural settlement, and suburbanization of wildlands (Lara et al. 1996, Armesto et al. 2001, Herrmann 2005, Barreau et al. 2019). As people (*che*) of the land (*mapu*), the resilience of Mapuche culture is directly tied to the health of native forests (Rozzi et al. 2008) and thus has been greatly impacted by centuries of land grabbing, assimilation, and displacement (Bengoa 2003, Coña and de Moesbach 2010, Montalba and Stephens 2014). More recently, changing social-ecological processes have also affected campesino communities. Many campesinos settled in the territory after receiving land claims during the 19th century State-sponsored *Pacificación de La Araucanía* campaign, and since have lived for generations as small-scale agriculturalists (Bengoa 2000). As such, they hold in-depth and seasoned knowledge of the forests. Today, many campesinos are being parceled out of their properties by rural gentrification (Marchant Santiago 2017, Monterrubio-Solís et al. 2023).

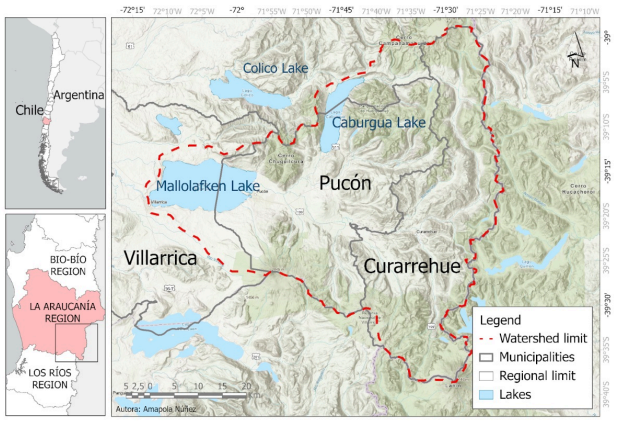
Given the changing social-ecological landscape of the region, and building from previous research that has demonstrated *Chusquea* spp.' critical role in forest ecological structure and dynamics (Veblen 1982, Caviedes and Ibarra 2017, Ibarra et al. 2018), it is important to understand the biocultural role and TEK associated with native bamboo to guide future forest management decisions. Hence, we first aim to evaluate the extent to which we can consider native bamboo as an assemblage of biocultural keystone species within campesino and Mapuche communities in the southern Andes. Second, we present an overview of current TEK and assesses the state of biocultural memory. To do so, we conducted an ethnographic study that accessed native bamboo along the criteria of the cultural keystone species concept (Garibaldi and Turner 2004). Moreover, we relied on community-based participatory frameworks (Méndez et al. 2017, Rossier 2019, Sowerwine et al. 2019, Evans et al. 2022, Ibarra et al. 2023) to guide the research goals and redistribution of results.

METHODS

Study area

This study was conducted in the watershed of Lake Mallolafken (or Villarrica), spanning the municipalities of Villarrica, Pucón, and Curarrehue, in the Andean zone of the La Araucanía region of southern Chile (39ºS). The region is characterized by a temperate climate with a short dry season (< 4 months). Over the last decade, the mean annual temperature has been 12°C, with temperatures varying from 0.8 to 28°C, and a mean annual precipitation of 2143 mm. The area is shaped by volcanic and mountainous topography, with vegetation dominated by *Nothofagus obliqua* at lower elevations (200–1000 m) and mixed deciduous *Nothofagus pumilio* and the conifer *Araucaria araucana* at higher elevations (1000–1500 m) (Gajardo 1995). These native temperate forests funnel into valleys and extend down to rivers and lakes, where most settlement and small-scale agricultural activities are contained. The aforementioned municipal districts are within Wallmapu, the ancestral homelands of the Mapuche people (Fig. 2).

Fig. 2. Location of the study area within the Mallolafken (Villarrica) watershed (39°S 71°W) in the southern Andes of Chile.



Fieldwork

We used a community-based participatory approach and relied principally on ethnographic techniques over the course of nine months of fieldwork, between March and November 2023, in the Mallolafken watershed. The first stage of the work consisted of obtaining free and informed consent from interviewees, building relationships with local foragers, and being introduced to their networks of fellow foragers and related community groups. Participant observation took place during community events, including workshops, community work days or *mingas*, seed exchange gatherings or *trafkintu*, and foraging sessions. During participant observation, a series of 50 informal interviews were conducted with relevant local actors (Charmaz 2006, Kovach 2009). They represented both campesino and Mapuche residents of the Mallolafken watershed who shared perspectives principally from personal experience managing and using the *Chusquea* species on their lands. These actors did not claim extensive bamboo foraging knowledge; thus, their perspectives were understood as providing a more representative picture of the present cultural salience and biocultural memory of bamboo use. We either asked interviewees about specific and often context-relevant topics (i.e., harvesting techniques and edible preparation, while collecting bamboo shoots) or provided open-ended discussion opportunities to gain general insights into biocultural memory. Furthermore, 16 in-depth, semi-structured interviews were conducted with expert foragers. These key local actors were identified by successive referral sampling (Atkinson and Flint 2001, Bernard 2011, Voicu and Babonea 2011). Of the expert foragers who participated in these interviews, 40% identified as Mapuche; 60% identified as Campesino. The interviewees' ages ranged from 39 to 79 years, with a medium age of 56 years, and 70% had a lifetime of bamboo harvesting experience; overall, interviewees averaged 55 years of experience harvesting bamboo. All interviewees harvested bamboo from their personal property or that of adjacent neighbors. Their foraging areas were located in the valleys and foothills, between 250 and 1000 m, where native bamboo grew in both cleared pasture and the understory of forested tracks, particularly along streams. There was an equal ratio of male to female foragers, who ranged in profession and educational background: most had completed up to primary education and worked in land-based trades. The interviewees varied in their principal use of bamboo, given their diverse backgrounds as gardeners, ranchers, weavers, carpenters, traditional healers, artisans, and chefs.

In our formal interviews, we asked about native bamboo according to each component of a cultural keystone species outlined by Garibaldi and Turner (2004). We included questions tailored to each of the six CKS criteria to identify (1) uses and frequencies of use, (2) ethnotaxonomic diversity and nomenclature, (3) associated folklore, spirituality, and ceremonial roles, (4) social reputation and cultural salience of use and symbolism, (5) irreplaceability, and (6) frequency and value of trade (Table 1). Open-ended discussion points, such as "What does the kila/koliwe mean to you?" and "What significance, if any, does the kila/koliwe hold for you?", were also included to address the potential limitations and inherent subjectivity of using solely CKS designations to understand the cultural importance of *Chusquea* spp.

Table 1. Interview questions associated with cultural keystone species (CKS) criteria.

CKS criteria	Interview questions
Intensity, type, and multiplicity of use	In what ways do you use the *Chusquea* spp.? Are there other uses that you know of but do not personally practice? How often do you use [use type]? How do you make [use type] from the *Chusquea* spp.?
Naming and terminology in a language	If you consider the species of [*Chusquea* spp.] bamboo that grows in this area, how many types would you say there are? What do you call them? Are there any other names you use to refer to these plants? Are there any other names you have heard but do not personally use?
Role in narratives, ceremonies, or symbolism	Do you know of any myths, symbols, or histories associated with *Chusquea* spp. bamboo? What do they say? Are you familiar with any ceremonial purposes or spiritual uses of *Chusquea* spp.?
Persistence and memory of use in relationship to cultural change	How would you describe the general reputation of *Chusquea* spp. today? Are their many people in your community who use the species or know of its uses? What about beyond your community in Wallmapu at large? What is the process of harvesting *Chusquea* spp.? When harvesting *Chusquea* spp., what factors tell you a shoot or stock is ready to harvest? And what factors indicate it is of high or low quality? How do you take care of bamboo habitat? Do you ever do anything to help the plant grow better?
Level of unique position in culture	Of the aforementioned uses, are there other plants that might be used in place of the *Chusquea* spp. bamboo to fulfill the same purposes?
Opportunities for trade beyond the territory	Is the *Chusquea* spp. ever traded? Today, does there exist relevant commercial value or trade opportunities for bamboo? What about historically? Do you know of any uses for the species distinct from those beyond the Mallolafken watershed?

Furthermore, we asked interviewees about harvesting practices, species management, and aspects of local biocultural memory associated with bamboo to further broaden our evaluation of the *Chusquea* spp. beyond the CKS indices. Weather permitting, interviews were accompanied by a walk to assist in harvesting and/or review the quality and growth available within participants' foraging areas. The total interview time with each interviewee ranged from 3 to 6 hours. Additional written notes were taken during each interview and were followed up with a detailed memo, including follow-up questions to address during either supplementary visits or a phone call.

Audio recordings were transcribed and analyzed using a priori codes related to each of the six CKS criteria, as well as with open coding to allow emergent themes to arise (Strauss and Corbin 1998). Responses were compared across interviewees and then across existing literature to identify areas of agreement and disagreement, as well as unique responses. Foraging metrics were deduced by using inductive coding, were compared across interviewees, and were reviewed during follow-up conversations (Chandra and Shang 2019). Relevant ethnographic and ethnobotanical literature was also searched for references to *Chusquea* spp. harvesting, management, and cultural importance (González Cangas and González 2006, Campos et al. 2010, Cordero et al. 2022, Hilger and Mondloch 2021).

RESULTS

People and bamboo in the southern Andes: an assemblage of biocultural keystone species?

Chusquea spp. use

"The kila is everything. It's gold in the countryside." The words of this Mapuche weaver reflected the sentiments of many Indigenous and campesino foragers local to the Mallolafken watershed who harvest bamboo for different purposes. While popular reverence for *Chusquea* spp. has largely declined, drawing controversy for their association with rodent outbreaks and often confused as non-native species, rural use of native bamboo promotes an alternative appreciation for its diverse offerings. Among campesinos and Mapuche foragers in the Mallolafken watershed, we found native bamboo remains a critical, though waning, resource that supports several aspects of daily life in rural areas.

We identified 62 current household uses of *Chusquea* spp. (Fig. 3). The uses can be broadly grouped in terms of (1) home goods, (2) food and kitchen, (3) artisanry, (4) home gardening (5) carpentry, (6) spirituality, (7) ranching, (8) construction, and (9) historical uses (Table 2). Each participant listed, on average, 18 personal uses of bamboo, plus an average of four additional uses they knew of but did not personally practice. Notably, unlike our overall total, this measurement was based on classification only to a general level; hence, "furniture" was counted as one use type, although several participants presented multiple examples of bamboo furniture, such as chairs, benches, tables, and bed frames. Additional uses were determined through participant observation and follow-up discussion.

Fig. 3. Some uses of native bamboo in the southern Andes: (A) greenhouse frame, (B) chair, (C) fishing rod, (D) Mapuche loom, (E) koliwe (*Chusquea culeou*) shoots, (F) bamboo spoons.



Table 2. Use types of native bamboo in the Mallolafken watershed, southern Andes of Chile.

Domain	Use	Total
Home goods	Kindling, torches, charcoal pens, ink holders, broom handles, chimney cleaners, umbrella holders, curtain rods, drying racks (clothes), hiking sticks, walking canes, crutches	12
Food/kitchen	Raw vegetable shoots, conserves, grain meal, rice-like preparation of seeds, fishing rods, skewers and other utensils, meat smokers, zarrandas (cheese drying racks), cutting boards	10
Artisanry	Lamps, baskets, knitting needles, wool hand spinners (Aspa), natural dyes, carton/paper, kites, guiño (hockey-like sticks used in Mapuche pastime *chueka*), bicycles, and children's toys	10
Home gardening	Trellising, fruit pickers, tree tutors, greenhouse frames, llepü (winnow baskets), pollera (chick feed fences), ornamental	7
Carpentry	Tables, chairs, benches, bed frames, hammocks, cribs	6
Spirituality	Trutruka (Mapuche instruments used in ceremony), drum sticks, pipes, flag holders, altar contributions, medicine	6
Ranching	Animal fodder, herding sticks, animal bedding, animal refuges, oxen rings	5
Construction	Roofing, walls, gates, fencing	4
Historical uses	Pica (spears), baby walkers	2
Total		62

While bamboo does not constitute a caloric staple in the Mapuche or campesino diet, it may still be regarded as important to their food security. Historically, *Chusquea* spp. seeds were collected and cooked similarly to rice or were milled into grain (Cordero et al. 2022). Today, shoots are still collected in the spring and are consumed in several forms, including boiled, roasted, or canned to increase winter food supplies. The creativity in cooking *Chusquea* spp. was described to come from periods of scarcity, when communities turned to the plant, which is otherwise reserved as animal forage, to meet their own nutritional needs.

The *Chusquea* spp. also stand out for their technological support across home gardening and ranching activities. Their applications include animal fencing, crop trellising, and greenhouse frames. Koliwe, in particular, is also commonly crafted into traditional agricultural tools, such as *polleras* (bamboo fences that impede grown chickens from eating chick feed), *zarrandas* (bamboo-slatted racks used to smoke/dry meat and ferment cheese), and *llepüs* (flat woven baskets used to winnow grains). Particularly long bamboo stocks are used for fruit picking and springtime foraging of highly coveted digüeñe (*Cyttaria espinosae*). Additionally, ranchers often reserve rangeland sectors with abundant bamboo growth for chicken egg laying and winter grazing, as well as for collecting foliage for sheep pen bedding. While the *Chusquea* spp. might not be a remarkable caloric or nutritive food source in Mapuche or campesino households, their profound persistence within farming, ranching, foraging, and fishing activities alike begins to underscore their keystone role within daily life.

For centuries, Mapuche communities have relied on *Chusquea* spp. to construct their *rukas* (traditional houses) because they add rigidity to walls and roofing (Whitman et al. 2014). In recent years, locals have shown increased interest in exploring bioconstruction techniques and practices for building with *Chusquea* spp. While the bamboo stocks typically reach a diameter of only 2–3 cm, unlike Polynesian varieties, they are solid and thus can be grouped to meet structural needs (Whitman et al. 2014). The use of bioconstruction techniques was less common among the campesino and Mapuche foragers we interviewed: simple roofs, fences, and furniture were the most frequently cited construction applications. However, according to participants, native bamboo use (especially of koliwe) in sustainable design represents a compelling pathway to revitalizing the species' importance.

Due to their local abundance, affordability, and relative durability, *Chusquea* spp. fill the role of most household staples. *Chusquea* spp. are made into everyday essentials, such as utensils, are pruned and dried for kindling, and are crafted into torches, which was especially common before electricity arrived in the countryside. Moreover, *Chusquea* spp. are also a primary material for furniture and carpentry needs. Therein, *Chusquea* spp. remain central to several artisan traditions. In the territory, long stocks of *Chusquea* spp. are used as weaving material in traditional lampworking and basketry. Mapuche weavers use koliwe to build *witrals* (looms), and craft *tononwe* and *rangiñelwe*, tools that create tension and hold the yarn. Some weavers reported using koliwe as a natural wool dye. Mapuche artisans also craft instruments, children's toys, and sports equipment from native bamboo.

Ethnotaxonomy

All interviewees were able to list the two most common local bamboo varieties: *Chusquea culeou* and *C. quila*. Some interviewees lacked the scientific verbiage to characterize them as distinct species, referring to *C. quila* as the "older" version or "cousin" of *C. culeou.* The same naming systems we identified were consistent among interviewees and with the literature: *C. culeou* was referred to as koliwe, *C. quila* as kila or kilautre, and bamboo stands as kilatral or koligual. We also observed examples of specialized terminology related to tools and uses of bamboo, as described in the *Chusquea spp. use* section. Here, spelling varied greatly, a possible combination of the interviewees' limited formal educational levels and the oral-based traditions of Mapuche culture (Barreau et al. 2016).

Socio-cosmology of native bamboo as a messenger, protector, and companion

When asked about the symbolism of *Chusquea* spp., foragers unanimously brought up the belief that bamboo flowering served as a bad omen for a period of forthcoming scarcity. Today, many associate such scarcity with *ratadas*—outbreaks in rodent populations due to increased volume of food supplies from the abundant seed stock—that often get into household food supplies. However, the omen's mysticism is not all lost on residents; many recounted seeing flowering bamboo before the COVID-19 pandemic. Notably, the perspectives of Mapuche foragers offered a further understanding of flowering episodes, explaining the *Chusquea* spp.' role as a messenger.

Many Mapuche foragers shared that the bamboo flowering represented a call to prepare for elongated periods of hardship. One forager told the story of a volcanic eruption, following a flowering episode, that covered his property in several centimeters of ash. While he recounted the associated hardships, he also remarked that the nutrients from the ash eventually helped fertilize his pasture and contributed to future years of abundance. Similar stories brought depth to the understanding of native bamboo beyond a totem for scarcity. Another Mapuche forager traced the omen back to the first wave of colonization, sharing the legend that just before contact, the bamboo flowered in Wallmapu, and subsequently caused the first *ratada*. At the time, the appearance of non-native rodents served as a profound warning and call to action for the Mapuche Nation. During that time, bamboo was revered as a protector, as it was said, "As long as there is koliwe on our land, as long as there is koliwe to make our spears, the huinca, the invader, will not pass." Huinca, a Mapuche term, refers to non-Mapuche white Chileans and Argentines.

The image of the *Chusquea* spp. as a protector, on one hand, can be attributed to their role in the defense of Wallmapu. Beyond issuing warning signals or simply serving as a backbone of many households, bamboo was fashioned into weaponry, including spears, and was used to create mazes through the forest (González Cangas and González 2006). But, in addition to their practical contributions, *Chusquea* spp. are considered to be endowed with spiritual qualities of protection and companionship. As one forager remarked, "The koliwe is very important in our culture. It's very wise, like a brother. It's at your service. It takes care of you, heals you, [and] accompanies you." For these reasons, *Chusquea* spp. stocks are used as hiking sticks, and their leaves are used to lay beds where machis', traditional Mapuche healers, treat patients.

Koliwe's vertical form, in particular, is said to connect *wenu mapu* (the land of above or the "heavens") with *wallmapu* (the land and name of the Mapuche territory). Many foragers referred to its spirituality and symbolism as a messenger, protector, and companion. Among Mapuche culture, dreams play a powerful role in transmitting wisdom (Barreau 2014). Burning koliwe and placing its coals under a person's pillow was said to help them remember dreams, and the appearance of koliwe in dreams signals an important message is being communicated. Given their spirituality, *Chusquea* spp. are included in rewes (Mapuche altars) and in several ceremonial elements, such as pipes, flag holders, and the *trutruka* (a trumpet-like wind instrument). Machis' also use *Chusquea* spp. for their medicinal properties. One interviewee explained that the liquid derived from stocks, captured when heating stocks over a flame, is used to treat muscle pain and soreness. Further archival research showed that *Chusquea* spp. are also used to treat menopause symptoms and sexual impotence, and to relieve molar pain, and are used as a natural contra-contraceptive (Cordero et al. 2022).

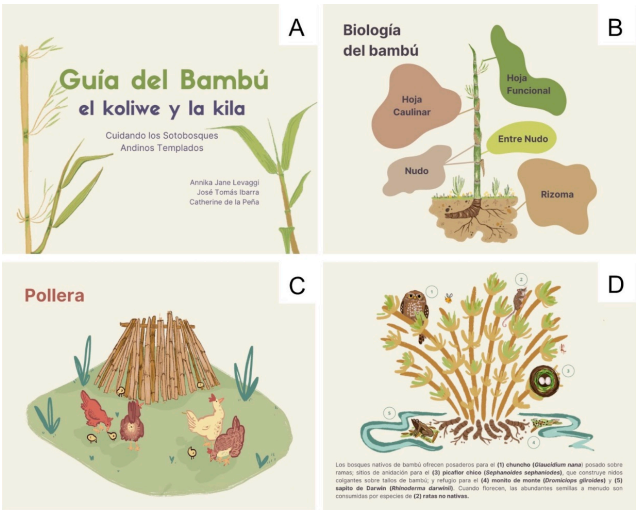
Cultural persistence

Despite their profound versatility, cultural importance, and ecological role among temperate forests, outside of Mapuche and campesino communities the *Chusquea* spp.' likeness remains tenuous. During our interviews, foragers were asked about their community's perception of the species and their broader social reputation. There was consistent agreement that foraging practices and cultural knowledge are being lost. Foragers remarked that very few community members remembered the intricacies of harvesting, and even fewer remembered the craftsmanship of use. While internal community knowledge networks were perceived as fragile, foragers unanimously remarked that those who had left the countryside to live in urban centers had also left behind *Chusquea* spp. foraging practices. Among conversations with non-foragers, it was not uncommon for them to refer to *Chusquea* spp. as either invasive or a weed. Most commonly, foragers attributed the decline in use and knowledge to changes in education, the rural youth exodus away from the countryside, and the increased privatization of land by "lifestyle" migrants. Foragers were in consensus that there is a lack of information on the importance, use, and conservation of native bamboo. Such missing resources were often attributed to the behaviors of the aforementioned "lifestyle" migrants, who were described as focusing their attention, upon purchasing land, on removing native bamboo to "clean up" their properties. Given the community-based framework of our project, we worked with foragers to create an accessible guide that included information about the ecological role, distinct uses, detailed harvesting guidelines, and basic management practices for *Chusquea* spp. (Fig. 4). The guide was shared with project participants, a network of local school teachers, and other inhabitants with the intention of improving education about native bamboo.

Replaceability

Given the breadth of use types of *Chusquea* spp., we did not identify other native species that rivaled their versatility. However, we did observe larger social-ecological shifts in the territory that are impacting the use and perception of bamboo in the area. Notably, the use of exotic species, namely pine (*Pinus* spp.), that were introduced appeared to be preferred over the use of bamboo in certain historical construction forms. For example, one forager

Fig. 4. Selected pages from the community manual on native bamboo: (A) cover page, (B) biological morphology, (C) example image of household uses, (D) image of ecological role and associated wildlife species.



noted that she prefers building her greenhouses from lumber because the short-roofed form of bamboo greenhouses does not provide her with sufficient planting space. When it came to the consumption of shoots, some foragers suggested that gathering shoots is less popular, given the association of wild edibles with poverty and their replacement with industrial commodities. Cruz-García (2006) found that especially among younger generations, increased consumption of market foods in place of wild edibles has become a status symbol. In other cases, preference changes were driven by questions of accessibility. One family noted that since the last flowering event, they have not been able to find harvest-quality bamboo, while others described having to cross into their neighbor's property to forage. The question of forest accessibility has been well documented in the region, as privatization and parcelization represent leading barriers to foraging wild resources (Barreau 2014, Barreau et al. 2016).

Pertinence to trade and economic opportunities

We recorded several instances of trade pertaining to the artisanal traditions associated with *Chusquea* spp., particularly their applications in food preparation, craft, carpentry, and construction. However, bamboo craft was largely contained to small-scale artisanal practices, while construction with bamboo was often linked to its relative affordability. Some interviewees also mentioned trading raw materials between neighbors or at larger export scales; however, such activities appeared uncommon due to the species' abundance in the region. Hence, the *Chusquea* spp., while implicated in trade, did not appear to have a high economic value.

Traditional Ecological Knowledge: foraging native bamboo

Traditional Ecological Knowledge is a practice of embodied knowledge rooted in a particular place (Ingold 2012). With Mapuche pedagogy, transmission of TEK is oral and in situ, or learned by doing. Likewise, many of the campesino households we interviewed described learning about bamboo foraging through similar processes of accompanying caretakers. However, the erosion of TEK has been recorded as a consequence of rapid social-ecological transformation in the region (Barreau et al. 2016). Hence, as part of understanding the state of the biocultural memory of *Chusquea* spp., we accompanied foragers and asked them about gathering practices and associated TEK.

Quality metrics and harvesting considerations

Foraging *Chusquea* spp. appeared to be embedded within cultural practices similar to other foraged products. Interviewees explained that they harvest only for specific and predetermined uses, take only small proportions of what is available, ask for permission to harvest, and leave offerings. Foragers shared beliefs about how much to harvest and when—including skipping foraging seasons altogether after mass-flowering events to allow for species regeneration.

Gathering *Chusquea* spp. stocks did not appear to be bound to any particular season, like seeds or mushrooms, or by a maturity scale, like berry ripeness or tree age. Rather, every *Chusquea* spp. stock has a use. Based on our interviews, harvesting *Chusquea* spp. depends on the intended use and then principally on (1) color, (2) width (stock diameter), (3) flexibility, (4) amount of leaves, (5) stock height, and (6) stock shape. Color was unanimously considered the most reliable indicator of maturity; young stocks have a distinct green tincture that turns yellow with age, and then the stocks become gray, dry, and brittle (Campos et al. 2010). Width was usually classified into three categories. Thin stocks (< 2 cm) are favored for detail-oriented work such as ornamental construction. Medium stocks (~2 cm, which is the most common diameter of a mature stock) are used most frequently for meeting household needs, such as trellising, broom handles, or knitting needles. Thick stocks (> 2 cm) are reserved for structural applications or for uses that require cutting a stock into length-wise segments, such as for basketry or spoon making. Flexibility, which is largely a proxy for age because the lignification process increases rigidity once the stock reaches maturity, refers to the ease with which a stock could be curved or bent. Flexibility is important for certain uses, such as building greenhouses or making fishing rods, which require ductile stocks; however, the opposite is true for applications such as making furniture or roofing. Artisanal practitioners often noted using fire to flex stocks when greater curvature is desired, such as when crafting snowshoes. The amount of leaves was used as a proxy for stock age and flexibility because young stocks retain their culm sheaths until they finish lignification and become rigid (Campos et al. 2010). Height was considered of secondary importance because most plants growing in foraging zones easily reach heights that surpass foragers' needs. Only in certain cases, such as for basket weaving or fruit picking, did height become a primary factor to consider. Similarly, stock shape was a factor in unique circumstances and referred to whether a stock grew uniformly straight or had natural curvature, such as when a stock grew around a fallen log. The latter case was sought after in particular when foraging for *guiños*. Notably, harvesting bamboo shoots for consumption followed a more uniform set of guidelines (Table 3). Shoot foraging occurs in the spring, from September until early November. Only shoots that reach ~16 cm tall, have purple leaves, a diameter of at least 1.5 cm, and are still relatively soft when squeezed should be harvested.

Habitat

Foragers were asked to characterize the habitat of *Chusquea* spp. generally, and then comment specifically about light availability, canopy coverage, altitude, water and humidity levels, temperature, grade/aspect, soil type, and species interactions. These metrics were selected because they represent relevant management-dependent variables.

Generally, foragers identified the habitat of *Chusquea* spp. with great consistency, naming streambed ravines as the most likely place to encounter harvestable *Chusquea* spp. Foragers noted that while *Chusquea* spp. seemed to prefer semi-shaded conditions, it was not uncommon to see the species thriving in open field pastures, which were often reserved by ranchers to maintain accessible forage for animal grazing purposes. When asked specifically about habitat variables, foragers offered a variety of observational analysis. One forager described the soil type by remarking how *Chusquea* spp. grow on his property from the edge of the forest to the rocky cliffs above his home, and he attributed the plants' own leaf matter to its ability to grow in diverse soil types. Another forager spoke about associated species by describing how she always finds the "best" and most orange changle (*Ramaria flava*) below *Chusquea* spp. groves. Several accounts described *Chusquea* spp. growing along various aspects, with several foragers remarking that their roots help stabilize soil and prevent erosion.

Table 3. Sample harvesting guidelines of *Chusquea* spp. bamboo in the southern Andes.

Chusquea spp. foraging index				
Use type	Color (purple, green, yellow, black, dry)	Width (thin, medium, thick)	Flexibility (highly, somewhat, none)	Other considerations
Furniture	Green or yellow	Thick for structural components, medium to thin for decorative work	None Somewhat for decorative work	Check for burrowing insects
Garden trellising	Yellow or dry	Medium	None	Yellow stocks last 1–3 farming seasons
Shoot conserve	Purple with yellow hues	Medium	N/A	Harvest when still soft, approximately 16 cm tall
Utensils	Yellow	Medium to thick	None	Check for burrowing insects
Knitting needles	Yellow	Thin to medium	None	Stalks should be straight
Fishing rods	Green with yellow hues	Thin to medium	Somewhat	Height should measure just above 1 m
Basketry	Green	Thick	Very	Taller (> 2 m) stocks are preferred

Table 4. *Chusquea* spp. habitat variables, according to forager accounts, in the Mallolafken watershed in the southern Andes.

Variable	Forager accounts
Light availability	Most *Chusquea* spp. prefer semi-shaded conditions; however, it is not uncommon for them to grow in all shade types, including full sun.
Canopy coverage	Most *Chusquea* spp. will grow below larger trees, although it is not uncommon to see them growing in full sun.
Altitude	*Chusquea* spp. are typically abundant in zones up to 1500 m, above which their growth was noted to be stunted, not reaching more than 2–2.5 m in height. Above 2000 m, they typically do not reach more than 1 m in height.
Water	*Chusquea* spp. grow near water, and their root systems are often partially inundated in stream beds.
Temperature	*Chusquea* spp. grow in cooler microclimates.
Grade	*Chusquea* spp. grow across all grades, including very steep hillsides. They are considered to prevent erosion.
Soil type	*Chusquea* spp. can grow in a variety of soils. They will often compact soil and create high duff levels with their own leaf foliage, which is thought to play a role in adding nutrients to the soil.
Species interactions	*Chusquea* spp. are most commonly associated with another commonly foraged species: *Ramaria flava* (Changle) and other plant varieties, including *Aristotelia chilensis* (Maqui), *Luma apiculata* (Arrayan), and *Araucaria araucana* (Pewen). They are also commonly associated with several small mammal and bird species.

Table 4 outlines the foragers' knowledge about management-relevant habitat variables of *Chusquea* spp. Notably, remarks about favored conditions became relevant when foragers were asked about management practices, especially when reproducing stands.

Management considerations

While many foragers denied managing or knowing of ways to manage native bamboo stands, several described activities that could be considered forest management. The most commonly described practices were pruning and reproduction. While only one forager explicitly named pruning as a management technique, several said that grazing animals naturally kept the bamboo on their property from growing intrusively. Foragers considered pruning by trimming stock ends through animal grazing, and clearing out dry or yellowed stocks for kindling or other uses as a critical active management form. While all foragers maintained close access to foraging areas, between 15 and 300 m from their homes, some described having planted select stands of *Chusquea* spp. on their property. Bamboo was most commonly planted via seed, rhizome transplant, or stock transplant. The latter was said to be the most successful reproductive method. Foragers affirmed the importance of transplanting stocks in areas according to the aforementioned habitat guidelines for optimal success, and some even noted observing improved growth in stands where they applied mulch and/or compost.

DISCUSSION

Our ethnographic research revealed in-depth Traditional Ecological Knowledge associated with the harvest and use of *Chusquea* spp. as both ancestral and current practices in the southern Andes. Information pertaining to use, harvest, and cultural significance of *Chusquea* spp. was far more abundant and a matter of greater agreement than management, in terms of either species regeneration or active care. Despite there being a growing community of novice foragers who are sharing uses for native bamboo through woodworking and bioconstruction workshops, and who are experimenting with species management, largely through pruning on personal property, ancestral practices did not appear as salient biocultural memory.

Considering the criteria outlined by Garibaldi and Turner (2004), we found that while native bamboo once appeared to be considered an assemblage of biocultural keystone species, today the biocultural memory of the *Chusquea* spp. remains considerably threatened. Building on previous research that demonstrated the ecological importance of *Chusquea* spp. (Veblen 1982, Altamirano et al. 2012, Caviedes and Ibarra 2017, Ibarra et al. 2018, Concha et al. 2023), we outlined the cultural significance of the assemblage of species belonging to the *Chusquea* genus in southern Andean temperate landscapes. Our assessment was based on the versatility and frequency of local bamboo use across pertinent cultural domains, including food production, construction, craftsmanship, and medicine, and more so, reflects *Chusquea* spp.' cultural regard through symbolism, storytelling, and spirituality (Table 5). At the same time, we observed a considerable decline in the persistence and memory of use of *Chusquea* spp. in relationship to cultural change. Other criteria—namely, terminology, level of unique position, and trade opportunities—were also assessed as supportive of a biocultural keystone species (BCKS) designation. We identified several naming schemes and associated terminology, found no other native species capable of fulfilling the breadth of material and/or spiritual roles of native bamboo, and recorded a variety of trade opportunities. Notably, while these three criteria were present, they also appeared particularly impacted by changing social-

Table 5. Biocultural keystone attributes of *Chusquea* spp. in the southern Andes.

Attribute	Indications of biocultural keystone species
Intensity, type, and multiplicity of use	62 identified historical and current uses related to construction, food production, medicine, artisanry, and spirituality.
Naming and terminology in a language	Several diverse naming schemes are used to refer to the species. Widespread use of Indigenous nomenclature in Mapudungun persists. *Chusquea quila* is referred to as kila or kilautre. *Chusquea culeou* is referred to as koliwe, colihue/coligue, coles, or rëngi. Caña de kila/koliwe is used to refer to bamboo stands. *Kilatral* or *koligual* refers to a forested sector dominated by bamboo.
Role in narratives, ceremonies, or symbolism	(i) *Chusquea* spp. are symbolized as messengers, protectors, and companions. (ii) The vertical stature of *Chusquea* spp. represents a connection between *wenu mapu* (the land above the "heavens") and *wallmapu* (the land and name of the Mapuche territory). (iii) Bamboo stocks have numerous uses in ceremonies and traditional healing practices.
Persistence and memory of use in relationship to cultural change	(i) *Chusquea* spp. are still used frequently and in diverse forms. (ii) Traditional Ecological Knowledge of *Chusquea* spp. use and harvesting remains widespread among rural and Indigenous communities. (iii) Myths of bamboo flowering seem to have been adopted by the greater Chilean culture.
Level of unique position in culture	While wood has been noted to be substituted for some of the construction-related uses of *Chusquea* species, no native species were found to replace the *Chusquea* species' breath of applications or their cultural role.
Extent to which they provide opportunities for resource acquisition from beyond the territory	*Chusquea* spp. are exchanged as raw materials for construction purposes and in the form of finished products (conserves, artisanal goods, etc.).

ecological conditions that have driven local Indigenous languages toward extinction, introduced several non-native species that have begun to displace certain bamboo uses, and increasingly replaced traditional trade systems with commercial markets (Klubock 2014, Barreau 2014, Moya-Santiagos and Quiroga-Curín 2022).

Notably, the cultural keystone species concept, which we adapted and expanded as the biocultural keystone species concept (Ibarra et al. 2012), has drawn debate for its conceptual ambiguities, lack of standardized evaluation methods, subjectivity of the people evaluating the criteria, and static and essentializing tendencies (Platten and Henfrey 2009, Cottee-Jones and Whittaker 2012, Coe and Gaoue 2020, Petelka et al. 2022). These limitations informed our qualitative and ethnographic approach to capturing narrative-driven knowledge of native bamboo from a diverse set of actors. Likewise, accessing the state of biocultural memory alongside BCKS qualifications allowed for a more dynamic conceptualization of how Andean communities' relationship with native bamboo has changed over time. While our ethnographic approach also supported our documentation of culturally sensitive TEK, our limited sample size highlights the need for future research that explores more systematic or intergenerational sampling to understand the depth of biocultural erosion. We also recognize that forests are complex adaptive systems (Messier and Puettmann 2011, Parrott and Meyer 2012, Ibarra et al. 2020). And specifically, that in degraded forests, such as where native bamboo thrives, emergent relationships between humans and more-than-humans are particularly adaptable in order to compensate for underlying social-ecological changes (Tsing 2015, Harraway 2016). While our study largely contends with human's cultural transformations with respect to bamboo, further studies that use transdisciplinary and multispecies lens are needed to better understand how human–bamboo relationships in the southern Andes might have fluctuated across social and ecological timescales and thus how the two might relate in the future to support social-ecological resilience (Ibarra et al. 2024b).

Previous studies that have identified biocultural keystone species have built cases upon the persistence and memory of use in relationship to cultural change—one of the six criteria forwarded by Garibaldi and Turner (2004). While our study identifies extensive native bamboo use and cosmology today, we also found limited management knowledge about native bamboo and a decline in use beyond rural communities. Similar results have been recorded in CKS assessments of case studies on the Andean condor (*Vultur gryphus*) and umbuzeiro tree (*Spondias tuberosa*), which reported diminished popular reverence for those species (Peroni et al. 2013, Jacques-Coper et al. 2019). We understand the general decline in native bamboo use not as a factor against its cultural importance but rather as a product of the changing social-ecological context. Here, the sensitivity of CKS to social-ecological changes represents one of the reasons why they are strategic focal points for conservation work (Garibaldi 2009, Uprety et al. 2017, Winter et al. 2018, Petelka et al. 2022, Axelsson and Franco 2023). Given that CKS are often vulnerable to human impacts at local scales (Moola et al. 2007, Baker 2021) and that their importance can decline concurrently with the cultures that nourish them (Cámara-Leret and Bascompte 2021, Ladle et al. 2023), our assessment of a decline in the *Chusquea* spp. as a BCKS underscores the importance of nurturing bamboo revitalization among campesino and Mapuche communities as a pathway for fostering both social and ecological resilience.

In a recent literature review, Mattalia et al. (2024) suggested that the CKS determination may be better conceptualized as a continuum according to gradients of relationship intensity. Within such a dynamic conceptualization of human and more-than-human interactions, *Chusquea* spp. can be considered an assemblage of biocultural keystone species, at the same time their biocultural memory appears considerably threatened. Despite use and harvesting practices being evidently salient, the fragmenting biocultural memory beyond the countryside raises concerns for greater regard and use of native bamboo. In addition to a reduction in the number of experienced bamboo foragers, threats to biocultural memory were observed via the lack of understanding of how to manage bamboo stands, especially along foraging needs. For example, we recorded few suggestions for how to manage a stand to produce taller or wider stocks. These declines in biocultural memory should be understood within the greater histories of loss of native Andean forest and ongoing legacies of

colonization, including land grabbing and assimilation (Bengoa 2003). While the expansion of agriculture and timber industries alongside urbanization have changed the local abundance and distribution of native bamboo, compounding socioeconomic transformations have also interrupted intergenerational cultural exchange, especially when it comes to passing down TEK within Indigenous communities (Coña and de Moesbach 2010, Montalba and Stephens 2014). Within the Mallolafken watershed, the decline of TEK has been linked to the exodus of Indigenous and campesino youth moving away from the countryside because many of them are unable to envision a future within rural economies (Schnettler et al. 2013). Also at play is the hyper-nationalization of education, which excludes TEK from the curriculum (Cruz-García 2006) and interrupts many social dynamics that would otherwise allow for intergenerational knowledge transfer, such as reducing children's time spent in the home (Krohn and Segrest 2010, Barreau 2014). Thus, efforts to revitalize bamboo TEK may help prevent further cultural loss while also supporting the ecological benefits of *Chusquea* spp. (Altamirano et al. 2012, Caviedes and Ibarra 2017, Ibarra et al. 2018).

Mattalia et al.'s (2024) literature review also suggests a CKS evaluation should explicitly acknowledge the reciprocal relationships between sociocultural groups and species. For this reason, we assessed the current TEK associated with native bamboo alongside Garibaldi and Turner's (2004) criteria—as reciprocity can largely be understood as the stewardship of a CKS and its habitat. However, we also understand stewardship of native bamboo, like any wild resources, in terms of "multispecies" interaction. In an attempt to undo traditions of essentialism within place-based conservation, sociologists derived the multispecies concept to suggest that not only have human communities influenced more than human species but that the reverse is also true (Ogden et al. 2013, Aisher and Damodaran 2016). Previously, Medrano and Rosso (2016) showed how biocultural keystone species can be implicated in these multispecies frameworks by describing how Qom Indigenous ontologies extend emotional and even kinship relationships with the ñandú's (*Rhea americana*). In their study, they write, "the [Qom] without the *rhea*, are not people." Similar to the ñandú, we might think of how not only have humans influenced *Chusquea* spp. but that bamboo has also shaped human life in the process of "becoming with" (Haraway 2016). The multispecies framework has often been invoked when considering degraded landscapes to suggest that the construction of multispecies worlds amid disturbance can offer hymns of biocultural hope (Tsing 2015). Famously, Tsing (2015) discussed how matsutake (*Tricholoma matsutake*) abundance can offer a guide for surviving capitalist ruins. In the southern Andes, the complex relationships between humans and native bamboo species can offer a similar conceptualization of multispecies interactions. If we remember, the *Chusquea* spp. once played a critical role in the defense of Wallmapu. Elder foragers said that following colonization and the subsequent large-scale disturbance to the native forests, the distribution of *Chusquea* spp. changed dramatically. According to ancestral accounts, there is less forgeable koliwe (*Chusquea culeou*) and more sprawling kila (*Chusquea quila*), which is making some areas of the forest impassable. With the multispecies lens, we might ask how might kila be protecting the forest anew? And, as pioneer species, what lessons might *Chusquea* spp. offer about thriving amidst ruins? Such questions invoke important alternative ontologies for considering how to nurture biocultural memory while challenging the essentializing tendencies of the biocultural keystone species concept, and in that way, can be important to consider when thinking about native bamboo's role in conservation.

The biocultural keystone species has been touted for its potential to support conservation work, particularly to identify species that could serve as strategic focal points for regeneration and/or monitoring (Garibaldi and Turner 2004, Garibaldi 2009, Butler et al. 2012, Costanza et al. 2016, Uprety et al. 2017). It has been suggested that the local interest and sense of place evoked by biocultural keystone species can help promote interest in conservation, while also aligning land management with cultural values. The identification of culturally critical species has been shown to protect Indigenous rights, in particular (Reyes-García et al. 2022). Successful applications can be seen in the case of the black ash in guiding wetland management (Costanza et al. 2017), and with the eastern white pine (*Pinus strobus* L.) in forest regeneration monitoring (Uprety et al. 2017). The similar social-ecological pertinence of *Chusquea* spp. suggests it might be a promising pathway for conservation. Foraging wild edibles in Andean forests has been shown to play a role in land stewardship, such as how gathering baskets can impact the distribution of mushroom spores (Barreau et al. 2016). While *Chusquea* spp. were previously misunderstood to encumber canopy growth (González et al. 2002, Muñoz et al. 2012) and their removal was linked to promoting natural regeneration in degraded forests (Bannister et al. 2024), further studies showed that *Chusquea* spp.' dominant post-disturbance growth can enhance understory health (Altamirano et al. 2012, Caviedes and Ibarra 2017, Ibarra et al. 2018). The *Chusquea* spp. have similar ecological services and cultural relevance as other Latin American bamboo species, such as the *Guadua*, which has likewise been a proposed focus of land management, given its pertinence among Amazonian tribes (Virtanen et al. 2022). That said, it should not be overlooked that native bamboo has dominated certain forested areas in a way that presents challenges to foragers, either because forage quality is low or forage is difficult to access. A better understanding of culturally relevant management of *Chusquea* spp. could support forest health alongside foragers' needs.

CONCLUSION

The role and use of *Chusquea* spp. among campesino and Mapuche communities in the southern Andes supports previous research that suggested the potential of non-timber forest products to be critical biocultural keystone species (Shakelton et al. 2018). However, it duly raises questions about how the understood biocultural values might be incorporated into broader forest management and conservation approaches. Such declining salience regarding native bamboo TEK underscores the importance of future research collaborations with foragers to identify and evaluate possible management strategies. While our study identified salient uses and foraging practices related to *Chusquea* spp., the little remaining Traditional Ecological Knowledge regarding species management reveals declining biocultural memory. We hope the quality assessment guidelines,

habitat considerations, and management best practices can serve as a starting point for future research to strive to better understand how to tend temperate Andean forests to support healthy and high-quality harvestable bamboo for the communities that rely on them.

Author Contributions:

Annika Levaggi: Conceptualization, methodology, investigation, formal analysis, writing – original draft, review and editing, visualization, funding acquisition José Tomás Ibarra: Conceptualization, writing – review and editing, supervision

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Data Availability:

The data and code that support the findings of this study are available on request from the corresponding author, AL. None of the data and code are publicly available because they contain information that could compromise the privacy of the research participants. Ethical approval for this research study was granted by the Ethics Committee of the Pontificia Universidad Católica de Chile, protocol code 190603004.

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