UNIVERSIDAD DE CHILE -FACULTAD DE CIENCIAS - ESCUELA DE PREGRADO

“Efectos del reemplazo de bosque nativo sobre el conocimiento y uso de plantas nativas con fines alimenticios”

Seminario de Título entregado a la Universidad de Chile en cumplimiento parcial de los requisitos para optar al Título de Biólogo Ambiental

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INFORME DE APROBACIÓN SEMINARIO DE TITULO

Se informa a la Escuela de Pregrado de la Facultad de Ciencias, de la Universidad de Chile que el Seminario de Título, presentado por el Sr. Santiago Agustín Parra Bulacio

“Efectos del reemplazo de bosque nativo sobre el conocimiento y uso de plantas nativas con fines alimenticios”

Ha sido aprobado por la Comisión de Evaluación, en cumplimiento parcial de los requisitos para optar al Título de Biólogo con mención Medio Ambiente.

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Santiago de Chile, ……………………………

Violeta, con su canto y su guitarra
transmitió los saberes, pesares y sueños
de hombres y mujeres
de valles, desiertos y montañas
del territorio al oeste de los Andes.

"Creciendo irán poco a poco,
Los alegres pensamientos,
Cuando ya estén florecidos,
Irá lejos tu recuerdo.
De la flor de la amapola,
Seré su mejor amiga,
La pondré bajo la almohada,
Para dormirme tranquila.

Cogollo de toronjil,
Cuando me aumente la pena,
Las flores de mi jardín,
Han de ser mis enfermeras.
Y si acaso yo me ausento,
Antes que tu arrepientas,
Heredarás estas flores,
Ven a curarte con ellas"

La Jardinera – Violeta Parra

AUTOBIOGRAFÍA

Desde pequeño sentí curiosidad de comprender el mundo natural, sus especies e interacciones. Durante la adolescencia fui dando forma a estas preguntas y a generar una particular sensibilidad con la crisis ecológica que como especie humana estamos ocasionando en diversos territorios del mundo entero. Estas inquietudes me llevaron a estudiar Biología Ambiental y a acercarme al área de la conservación biológica y la comprensión de las dinámicas socio-ecológicas. Durante la carrera respondí ciertas preguntas iniciales, sin embargo, en este proceso de estudio surgieron más y más preguntas cuyas respuestas seguiré buscando con nuevas experiencias de aprendizaje, con el objetivo de contribuir al anhelado cambio socioambiental que revolucione nuestra forma de relacionarnos entre humanos y que logre la cohabitación entre las diversas especies que alberga la tierra.

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Agradezco a cada persona que me acompañó, conversó y discutió conmigo en este proceso de aprendizaje.

A mi profesor guía, Javier Simonetti, por su entrega y dedicación a la enseñanza, por compartir sus conocimientos y su constante motivación, por su sentido del humor inagotable. A mi cotutor, Mauricio Folchi, por su rigurosidad investigativa y su paciencia para con nosotros: "los biólogos". Por ser pionero en esta loca idea de hacer investigación de una forma interdisciplinaria, buscando el diálogo entre distintos saberes.

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A mis amigos y amigas que he conocido en la universidad. Gracias por las vivencias, risas, penas y sueños compartidos.

Quiero agradecer a mi familia, pilar fundamental en este proceso. A Fredy y Constanza, mis padres, por inculcarme las ganas de aprender, su amor entregado y sabios consejos. A ustedes les debo la vida. Gracias por darme alas para volar. A mis hermanas, Sofía y Bethania, por su paciencia, compañía y cariño. A la Tía Maggi por sus enseñanzas que me forjaron como persona.

A Sofía Ahumada, compañera de mis días en estos años, por su empatía, comprensión, enseñanzas y amor entregado. Agradezco el día en que nuestras vidas se cruzaron. Gracias por todos los momentos vividos que ahora son hermosos recuerdos.

Por último, quiero agradecer a todos esos hombres y mujeres de Paredones y Arauco: habitantes rurales depositarios de una gran sabiduría, que pasan inadvertidos en la historia oficial. Con una acogida fraternal nos recibieron en sus hogares y nos compartieron felices sus saberes sobre plantas alimenticias, conocimiento fundamental e imprescindible en la presente investigación.

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RESUMEN

Las comunidades humanas, a través del uso de plantas alimenticias, han adquirido a lo largo de generaciones conocimientos de plantas nativas. Las transformaciones antrópicas del paisaje y de la vida moderna repercuten negativamente en las interacciones que el ser humano ha tenido históricamente con la naturaleza, lo cual ha generado un ciclo de separación del ser humano de su entorno natural llamado extinción de la experiencia. En Chile, dadas las recientes transformaciones en el paisaje, con la expansión de las plantaciones forestales en desmedro del bosque nativo, se estaría afectando negativamente el conocimiento de plantas nativas comestibles. En nuestra investigación se encuestaron 426 hogares en localidades rurales de Paredones y Arauco, dos comunas costeras del centro sur de Chile afectadas por la expansión forestal. Evaluamos la relación entre el conocimiento de plantas comestibles con el cambio de uso de suelo y atributos socioculturales de los habitantes rurales. Nuestros resultados indican que el reemplazo de bosque nativo por plantaciones forestales no ha afectado el conocimiento y uso de plantas comestibles. Sin embargo, la cobertura de bosque nativo disponible en la década de los 70' tiene un efecto positivo en el uso de estas plantas. Se infiere que los cambios en el paisaje se producen de manera más rápida que la erosión del conocimiento. Por lo cual a largo plazo se podrían dilucidar las consecuencias de las recientes pérdidas de bosque nativo en el conocimiento de plantas alimenticias. Además, constatamos que personas con trabajos ligados al campo, principalmente realizados por hombres, tienen un mayor conocimiento de plantas comestibles. Por lo tanto, las mujeres que principalmente se dedican a trabajos domésticos no tienen la oportunidad de conocer e interactuar con la naturaleza. Debido al desfase entre la pérdida de conocimiento y los cambios en el paisaje, deducimos que todavía hay tiempo de rescatar y valorar el conocimiento de plantas comestibles, por lo que proponemos generar instancias de difusión cultural dirigidas principalmente a mujeres y jóvenes.

ABSTRACT

Human communities have acquired knowledge of native plants over generations by using edible plants. Human landscape transformation and modern life negatively impact human interaction with nature, triggering a cycle of disconnection and ultimate separation between human and the natural environment: an extinction of experience. In Chile, given the recent landscape transformation, due to the replacement of native forests by plantations of exotic tree species, the knowledge of wild edible plants might be disappearing. Here, we perform 426 household surveys in rural localities of Paredones and Arauco, two coastal counties of south-central Chile affected by the expansion of forestry plantation. Then, we assess the relationship of edible plant knowledge with land use change and the sociocultural attributes of rural people. Our study shows that the replacement of native forests by plantations have not affected the knowledge and use of native edible plants. Nevertheless, this knowledge and use are positively related to the amount of native forest available by the 1970s. We suggest that knowledge loss occurs at a slower pace than land use change, and thus the consequences of the recent replacement of the natural landscape by exotic tree plantations could be expressed long-term.

Moreover, we point out that people with countryside jobs that are mainly performed by men have a higher knowledge of edible plants. Thus, women, the majority of which are housewives, do not have the opportunity to interact and know nature. Due to this lag between loss of knowledge and land use change, we surmise there is still time to rescue and value native edible plant knowledge, so we propose to generate instances of cultural diffusion aimed mainly at women and young people.

INTRODUCTION

Wild edible plants are still used by rural dwellers in developing countries (Bharucha and Pretty 2010; Cruz-Garcia et al. 2016), contributing to food security and to dietary diversity (Bharucha and Pretty 2010; Vincetti 2008). Further, wild food is an important income source for rural households in developing nations (Angelsen et al. 2014). The knowledge of wild edible plants based on empirical observations and beliefs represents experience acquires over the years through direct contact with the environment (Berkes 1993). Moreover, due to the traditional division of labour, women have a central role in gathering wild edible plants, hence they usually exhibit greater knowledge regarding this resource (Belahsen et al. 2016; Sommasang et al. 1998).

Worldwide, the knowledge and use of wild edible plants are being lost (Bharucha and Pretty 2010; Turner and Turner 2008). This decline might relate to sociocultural and environmental variables. The reduction of plant knowledge is associated with the modern life ranging across the disappearance of jobs in the countryside, rapid growth of people living in urban areas and industrialization (Benz et al. 2000; Menendez-Baceta et al. 2017; Miller 2005; Turner and Turner 2008), factors that reduce contact with nature, wild plants included. Hence, there is an intergenerational erosion of knowledge as the children receive less information than their parents (Reyes-García et al. 2013; Srithi et al. 2009).

On the other hand, biodiversity loss by human activities alters the functioning of ecosystems and their ability to provide goods and services to the society (Cardinale et al. 2012). Such loss can result in detrimental effects on food security through the reduction of access to wild foods (Myers et al. 2013). Therefore, the loss of biological diversity implies biologically impoverished living grounds, determining that people worldwide are interacting less and less with their natural environment (Kai et al. 2014, Soga and Gaston 2016, Turner et al. 2004). The loss of interaction between human and nature triggers an extinction of experience, that is: “a cycle of disconnection, apathy, and ultimate separation from nature” (Pyle 2003). When a species, either animal or plants become extinct of people’s daily environ, persons cannot experience that species. Thus, this local reduction in the absence or local extinction of the species triggers the loss of associated knowledge (Arenas et al. 2007; Giday et al. 2003; Kai et al. 2014; Pyle 2003). In fact, children living in biologically impoverished places like semi-urban and urban areas know a lesser diversity of native edible plants than children from rural areas (Eyssartier et al. 2017). Further, such an impoverishment coupled to greater distances of living grounds to the remnant forests, convey gathering of fewer species of non-timber forest products (Wickramasinghe et al. 1996).

In Chile, the expansion of forestry plantation from 1970’ has replaced native vegetation, agriculture and pasture land (Aguayo et al. 2009). The natural landscape in south-central Chile has undergone deforestation and fragmentation in the last decades (Echeverria et al. 2006) where native forests have mainly replaced by plantations of exotic tree species (Miranda et al. 2017). Nowadays, exotic forest plantations cover approximately 2.40 million hectares of the Chilean territory, mainly composed by *Pinus radiata* (Infor 2017). In addition, the areas of remaining native forests are currently located in sectors of difficult access, such as places with steep slopes or high altitudes

(Aguayo et al. 2009). Therefore, the extinction of experience might also be triggered by the replacement of native forests by monocultures of exotic species and the limited opportunities for people to interact with the remaining native vegetation, as might be the case for Chilean rural dwellers.

Wild plants have been used traditionally as food by Chilean rural people (de Moesbach 1992; Muñoz et al. 1981; Pardo and Pizarro 2013). Nevertheless, the knowledge of wild edible plants could be disappearing. Studies in Mapuche communities state that biodiversity loss along with the limited access and the great distance to the native forests and changes in agriculture systems due to overgrazing and mechanization appear to be significant factors acting negatively upon the use and gathering of wild plants (Egert and Godoy 2008; Ladio 2001; Peredo and Barrera 2005). Moreover, the school regime has left younger generations without the opportunity to learn about edible plants (Barreau et al. 2016).

Although several ethnobotanical studies have characterized the use of wild edible plants as well as explore different causes of declining in this knowledge, the presumed relationship between land use change with the knowledge and use of wild edible plants through time it is yet to be empirically assessed.

Within this framework, if the knowledge and use of native edible plants are shaped by native forests coverage, then it will be expected a diminished knowledge and use of native edible plants in rural dwellers which live in places with a higher replacement of native vegetation by exotic forest plantations. Hence, the main goal of the present study is to assess the impact that the replacement of native forests by exotic forest plantations has had on the knowledge and use of native edible plants in rural dwellers of the commune of Arauco and Paredones, two coastal territories of south-central Chile affected by the expansion of forestry plantation (Infor 2017). Specifically, we aim at (a) determine the number of known edible plants with respect to the maximum number of plants they could be aware of, (b) evaluate the relationship between the number of known and used wild edible plants with sociocultural attributes of rural people, (c) evaluate the relationship between the replacement of native forests by exotic forest plantations with the native edible plants known, species currently used and gathering patterns per rural residents in places affected by forestry plantations.

METHODS

Study Area

Research was conducted in Paredones (34°38'S,71°54'W) and Arauco (37°15'S,73°19'W), two coastal counties of south-central Chile (Figure 1). Landscape is a mosaic of native forest, shrubland, exotic tree plantation and pasture lands. Native forests cover 16% and 24% of the area in Paredones and Arauco, respectively (Figure 2 and 3). The native vegetation cover in Paredones is comprised of sclerophyllous forests dominated by *Lithrea caustica*, *Crytocarya alba* and *Azara integrifolia* (Luebert and Pliscoff 2006). In Arauco, vegetation is composed of sclerophyllous forest in coastal areas where the tree canopy is dominated by *Lithrea caustica*, *Crytocarya alba* and *Azara integrifolia*. In western slopes of the Coastal Mountain Range, the vegetational formation is deciduous forests dominated by *Nothofagus obliqua*, with species of laurel-leaved forests such as *Gomortega keule, Podocarpus saligna, Lapageria rosea* and *Gevuina avellana* (Luebert and Pliscoff 2006). In socio-economic terms, during the 1970s, prior to the expansion of forestry plantation, the presence of native forests in Paredones was already low (3.3%) due to the replacement of the natural landscape by rainfed agriculture and livestock land that were the principal economic activities. The forestry expansion has reduced significantly farming and livestock activities (Kukulis and Larraín 2017). Currently, monocultures of exotic species represent 49% of the communal surface (Figure 2). The rural population in Paredones have diminished 38% in the last decades which currently are 4 500 inhabitants (Kukulis and Larraín 2017). In Arauco, the economic were mainly agricultural, becoming in recent years to be mostly a forest economy (Pino 2016). At this time, monocultures of exotic species account for 44% of the communal surface (Figure 3). In Arauco, the rural dwellers are 10 604 (Pino 2016).

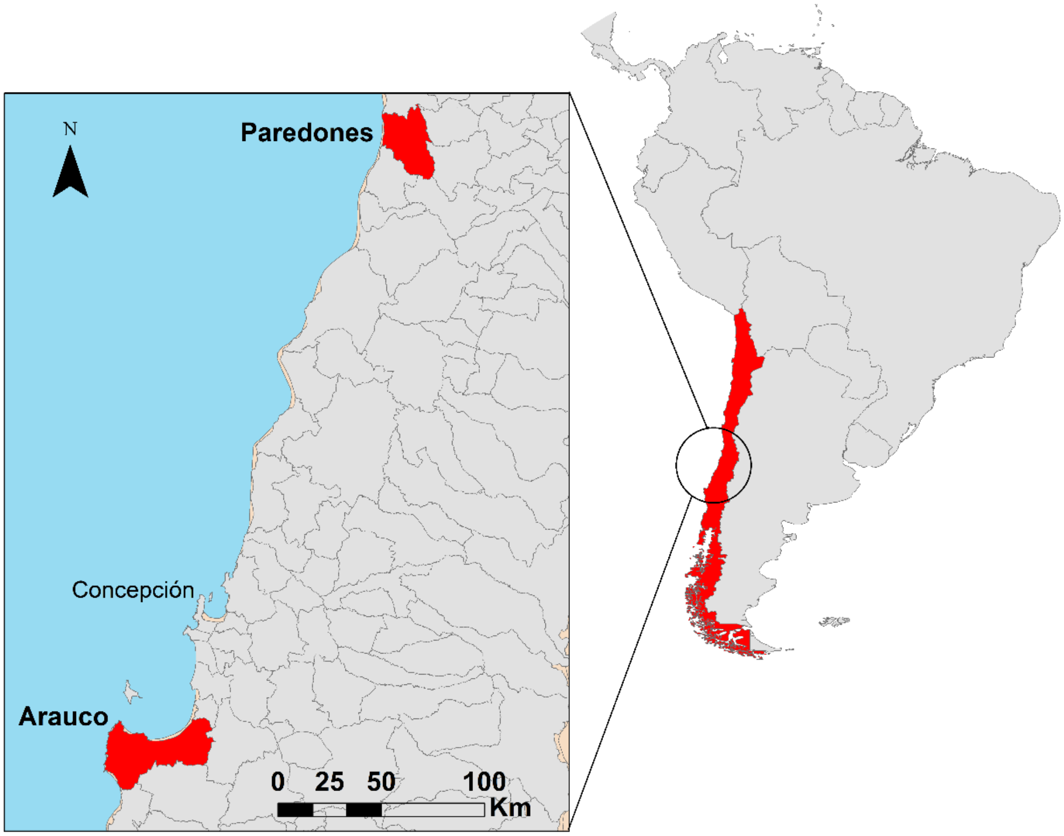


Figure 1. The field work was conducted in Paredones (34°38'S,71°54'W) and Arauco (37°15'S,73°19'W) two coastal communes of south-central Chile.

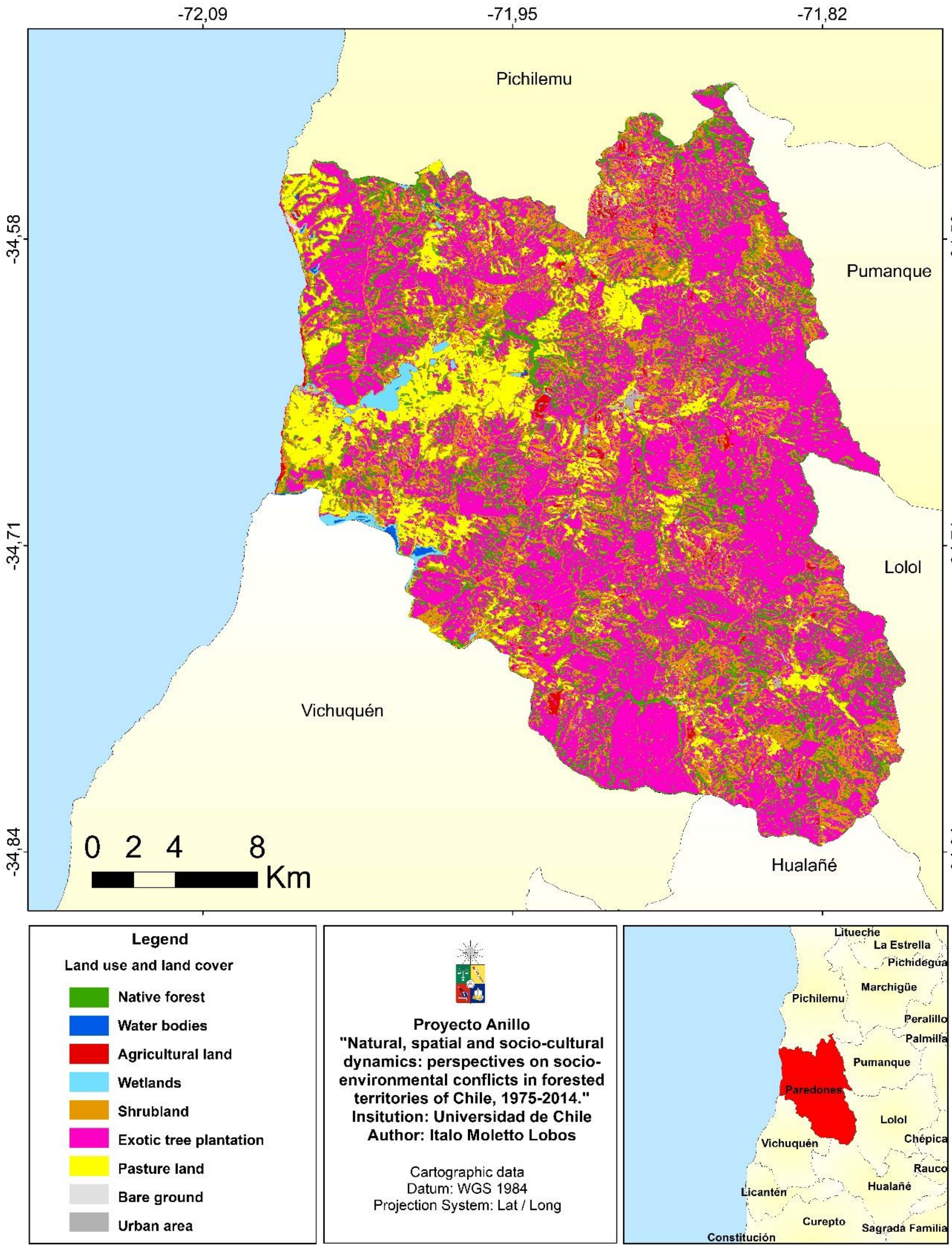


Figure 2. Current land use and land cover of Paredones commune. Cartographies elaborated by Proyecto Anillo (CONICYT PIA SOC 1404).

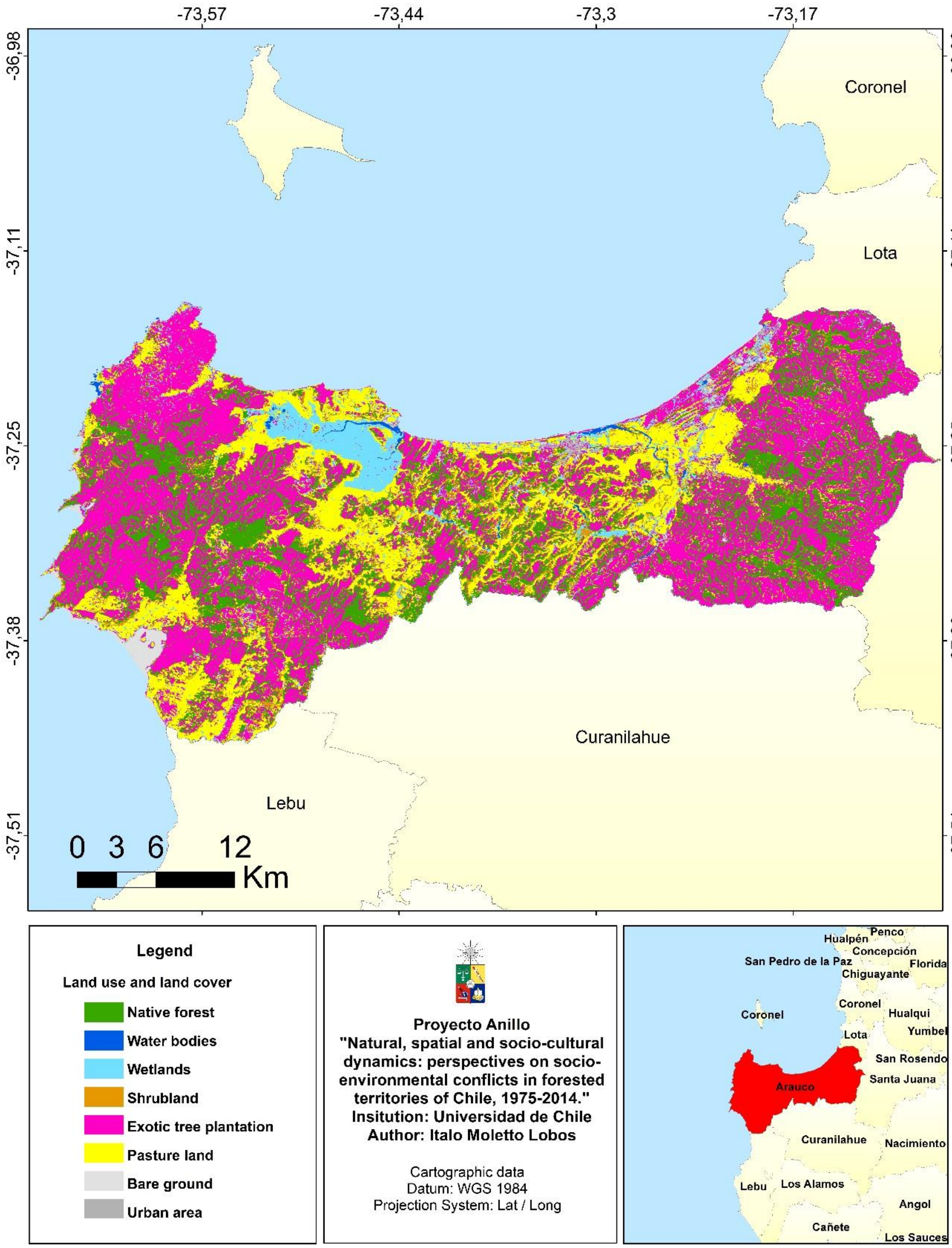


Figure 3. Current land use and land cover of Arauco commune. Cartographies elaborated by Proyecto Anillo (CONICYT PIA SOC 1404).

Data Collection

We conducted household surveys in rural localities with less than 1000 inhabitants (INE 2005). We gather information regarding what edible plants the rural dwellers known through the freelisting technique (Puri 2010). We also asked which of the plants known they did use during the last year and for the way in which such plants were obtained. If plants were gathered in the field, we further inquired regarding the gathering distances of plants harvested. We interviewed only one person per household and the informants should have over 18 years old.

In order to account sociocultural covariables that might affect knowledge and experience, we also registered the time of residency in the area, place of origin, age, gender, the educational level reached and job or occupation of each surveyed. A total of 193 interviews were carried out in Paredones at nine localities: El Calvario, El Potrero, La Ligua, Cabeceras, Querelema, La Quesería, Tierras Negras, Panilongo and La Capilla. A total of 233 household surveys were carried out in Arauco, at Bajo Raqui, Las Corrientes, Pichilo, Chillancito, El Parrón, Las Puentes, Llico, Los Maitenes and Rumena. The field work was carried out during the spring 2017.

To assess the availability of potential edible plants in the study area, we generated a database of native edible plants. We took into account: reviews that compiled the historic use of edible plants since pre-Hispanic times (Muñoz et al. 1981; Pardo and Pizarro 2013; Rapoport and Ladio 1999), ethnographic studies of decades with Mapuche communities in the south of Chile (de Moesbach 1992) and books that considered current use of edible plants (Cordero et al. 2017; Rapoport 2003a).

We evaluated land use change of Paredones and Arauco from cartographies elaborated by supervised classification through a Machine-Learning Random Forest. Sources of information were Landsat satellite images of 1975, 1979, 2014 and 2015 that were complemented with aerial photographs and field validation (Moletto 2018).

Data Analysis

To characterize de wild edible plant knowledge in the inhabitants of Paredones and Arauco, we analysed the frequency of each species listed and the average rank of the different species reported of the freelists of plants known, through a Smith's Salience Index (Puri 2010). This index is obtained by following the equation:

$$S_{ji} = (n_i - r_{ji} + 1) / n_i$$

where r refers to the ranking of element j in list i, and n to the number of elements in list i. The salience for an element in the complete sample corresponds to the average of the S of each list. The index goes from zero to one. Species with high salience are those mentioned by most informants and listed higher up in the freelist. On the contrary, plants named by fewer people and in the latest position in the freelist have low salience, near to 0. We considered both native and exotic plants to assess the incidence of exotic species into local knowledge.

To describe gathering patterns, we correlated the salience of each native species with their respective gathering distance. We also related maximum gathering distance reported by each interviewee with native forest coverage in the surrounding areas of that informant through Kendall correlation, as it is a two-sided test we utilized a significance level of 0.025.

In order to evaluate the effects of the replacement of native vegetation by exotic forest plantations with the number of native edible plants known and used, first we filtered the exotic species of each informant's freelist. Secondly, we assessed the coverage of native forest, shrubland, exotic tree plantation, pasture and agricultural land, in the 1970s and nowadays, in a circular area around the rural location surveyed (we performed the spatial analysis using QGIS 3.0). These areas were established considering the median gathering distances of native species that accumulated the 90% of the cumulative salience. As representative species in Paredones, we considered the gathering distances of *Aristotelia chilensis, Peumus boldus, Puya spp., Lardizabala biternata, Gunnera tinctoria, Ugni molinae* and *Ribes spp.* (Appendix Figure 4). In Arauco, we considered the gathering distances of *Aristotelia chilensis, Gunnera tinctoria, Ugni molinae, Peumus boldus, Gevuina avellana, Greigia sphacelata* and *Lapageria rosea* to establish this circular area around the rural locations (Appendix Figure 5). Thirdly, we realized multivariate analysis to evaluate the effects of explanatory variables of land use change and sociocultural covariate in the knowledge and use of native edible plants (Table 1). We utilized Poisson distribution (link = log) generalised linear mixed model in R statistical programme (package lme4, [Bates et al. 2014]). The hamlets where the informants were surveyed were included as random effects to account for non-independence answers from the interviewees from the same hamlets (Crawley 2012). In order to avoid collinearity in our model, we used a threshold correlation coefficient of $|r| \geq 0.7$ (Dormann et al. 2012).

Amid the explanatory and co-variables (Table 1), gender was significantly associated with job ($p < 0.0001$, Fisher's exact test). Thus, we consider the job in our generalised linear mixed model since the job is related closely with our extinction of experience hypothesis. Further, we excluded the interaction between rural experience and the amount of native forest available by 1970s upon plants' knowledge as there is a non-significant relationship (p-value = 0.29) between them.

Table 1. Summary of variable used in General linear mixed model.

Variable	Type	Description
Response variables		
Native edible plants known	Discrete	Variable comprised of the number of known native edible plants by each interviewee.
Native edible plants used	Discrete	Variable comprised of the number of native edible plants used the last year by each interviewee.
Explanatory variables		
Native forests 1970's	Continuous	Native forest coverage (%) in a circular area around the rural location surveyed in the 1970s.
Replacement of native forests	Continuous	Surface in the circular area around the rural location surveyed that in 1970s was native forest and currently is exotic forest plantation.
Sociocultural covariates		
Age	Discrete	Age of the person surveyed.
Education	Discrete	Educational level reached.
Gender	Categorical	2 categories: (0) women; (1) men
Job or occupation	Categorical	2 categories: (0) person with job not related to rural working; (1) person with occupation linked to the countryside as one of: seasonal fruit and vegetable pickers, farmer, gatherer or forest worker.
Rural experience	Categorical	We categorized the rural experience at (1) low rural experience; we groped persons who were born in urban environment and they arrived less than five years to a rural location, (2) intermediate rural experience; persons who were born in a rural area, then they migrated to an urban location and finally they have returned to the rural village. Also, in this category we groped persons who were born in urban environmental and they arrived more than five years to a rural location, (3) high rural experience; we assembled persons who have lived all their life in a rural environment.

RESULTS

We interviewed 426 people, 253 women and 173 men. The median age was 55 years and the mean of schooling was 7.5 years. People interviewed had lived an average of 39 years in the hamlets that they were surveyed. Concerning jobs, 276 persons did activities unrelated to rural activities, jobs that were mainly performed by women (77%). Conversely, 150 inhabitants did countryside jobs, activities related to the field, carried out mainly by men (73%).

The rural dwellers of Arauco and Paredones knew an average of 3.2 native edible species (median = 3) (Figure 6), 52 people did not know native plants and the maximum knowledge was a person that listed 12 native food plants. 32% of the plants known were exotic plants, an average of 1.4 exotic species (median = 1) listed per informants.

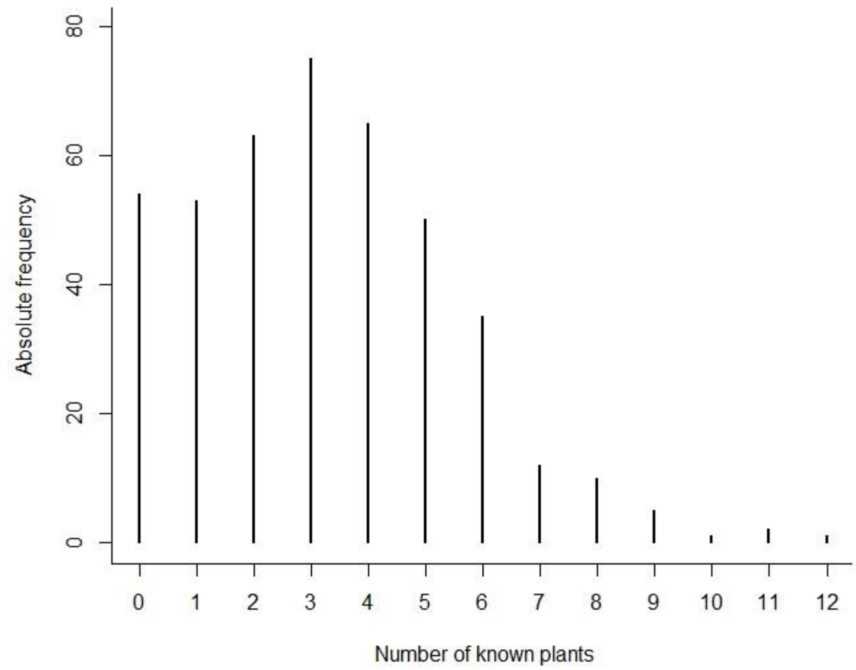


Figure 6. Frequency of known native plants by the interviewees in Arauco and Paredones, Chile.

Wild Edible Plants Diversity

A total of 81 wild edible plants were mentioned by rural dwellers in Paredones, 57 of them exotics (Appendix Table 2) and 24 native edible plants (Table 3) out a total of 70 available native species. In Arauco 64 food plants were listed, 36 exotic species (Appendix Table 4) and 28 native edible plants (Table 5) out a total of 81 potential edible plants (Figure 7). Fruits and seed were the most frequent plant part used (70%), secondly leaves, stems and flowers consumed raw as vegetables in salads (32%), and thirdly, underground edible parts (5%). The use of c*hin chin* (*Azara microphylla*) as food plant was the first known recorded, residents indicating its red fruits was as edible.

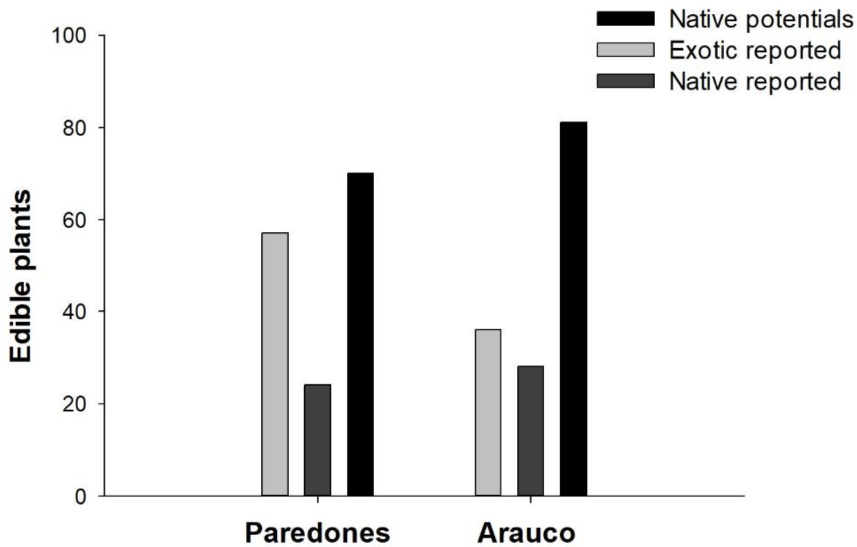


Figure 7. Native edible plants reported, native potential and exotic species reported in Paredones and Arauco.

Table 3. Native edible species reported in the commune of Paredones, 24 species in total, ordered by Smith´s Salience Index*.

Spanish name	**Scientific name**	**Salience index**	**Absolute frequency**
Maqui	*Aristotelia chilensis*	0.462	119
Boldo	*Peumus boldus*	0.406	114
Chagual	*Puya spp.*	0.113	36
Coile	*Lardizabala biternata*	0.095	40
Nalca, Pangue	*Gunnera tinctoria*	0.087	32
Mutilla	*Ugni molinae*	0.063	29
Zarzaparrilla, Parrilla	*Ribes spp.*	0.045	18
Michay	*Berberis spp.*	0.034	18
Palma Chilena	*Jubaea chilensis*	0.026	8
Chupón	*Ochagavia spp.*	0.017	10
Peumo	*Cryptocarya alba*	0.013	5
Quilo	*Muehlenbeckia hastulata*	0.012	6
Quintral del Maqui	*Tristerix corymbosus*	0.011	5
Pimpinela	*Margyricarpus pinnatus*	0.006	5
Frutilla Silvestre	*Fragaria chiloensis*	0.005	2
Espárrago de Mar	*Sarcocornia fruticosa*	0.005	1
Apio Silvestre	*Apium spp.*	0.004	1
Quintral del Boldo	*Notanthera heterophylla*	0.004	1
Avellano	*Gevuina avellana*	0.003	1
Cachayuyo	*Atriplex spp.*	0.003	1
Vinagrillo, Culle	*Oxalis spp.*	0.002	2
Tetilla	*Tetilla hydrocotylifolia*	0.002	2
Doca	*Carpobrotus aequilaterus*	0.001	2
Quisco	*Echinopsis chiloensis*	0.001	1

* Smith's Salience Index was carried out at the commune level with native and exotic plants. It should be mentioned that fungi were excluded to perform the salience index.

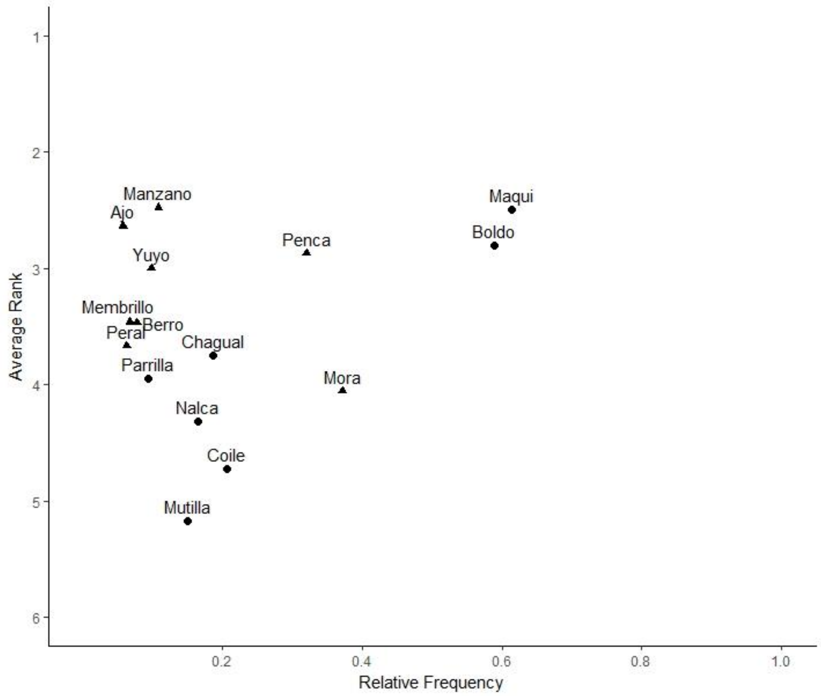
Table 5. Native edible species reported in the commune of Arauco, 28 species in total, ordered by Smith´s Salience Index*.

Spanish name	Scientific name	Salience index	Absolute frequency
Maqui	*Aristotelia chilensis*	0.4503	150
Mutilla, Murta	*Ugni molinae*	0.4392	157
Nalca	*Gunnera tinctoria*	0.4226	149
Boldo	*Peumus boldus*	0.2443	94
Avellano	*Gevuina avellana*	0.2200	87
Chupón	*Greigia sphacelata*	0.2104	84
Copihue	*Lapageria rosea*	0.0867	41
Coile, Coulle	*Lardizabala biternata*	0.0636	34
Zarzaparrilla	*Ribes spp.*	0.0380	21
Araucaria	*Araucaria araucana*	0.0337	19
Frutilla silvestre	*Fragaria chiloensis*	0.0303	16
Michay	*Berberis spp.*	0.0248	11
Doca	*Carpobrotus aequilaterus*	0.0179	12
Peumo	*Cryptocarya alba*	0.0151	8
Cuye, Vinagrillo	*Oxalis spp.*	0.0135	4
Placa	*Mimulus luteus*	0.0113	4
Chilco	*Fuchsia magellanica*	0.0095	5
Apio silvestre	*Apium spp.*	0.0079	2
Chupón pudeño, Chupón de Roca	*Ochagavia spp.*	0.0056	4
Arrayán	*Luma apiculata*	0.0052	5
Salvia	*Lepechinia spp*	0.0039	1
Chin Chin	*Azara microphylla*	0.0030	1
Papa Silvestre	*Solanum spp.*	0.0029	1
Pitarrilla	*Myrceugenia spp.*	0.0017	1
Sangrinaria	*Polygonum spp.*	0.0013	1
Canelo	*Drymis winteri*	0.0012	1
Chagual	*Puya spp.*	0.0007	1
Litre	*Lithrea caustica*	0.0002	1

* Smith's Salience Index was carried out at the commune level with native and exotic plants. It should be mentioned that fungi were excluded to perform the salience index.

In Paredones, *maqui* (*A. chilensis*, Smith's S index = 0.46), *boldo* (*P. boldus*, S = 0.41) and *penca* (*Cynara cardunculus*, S = 0.23) were the most salient species, plants that were frequently mentioned and listed higher up in the freelist. The first two plants are native and the third one is exotic. In the cultural domain of edible plants, only five species, out of the 81 plants reported, were mentioned for more than 20% of the people surveyed and two species, *maqui* (*A. chilensis*) and *boldo* (*P. boldus*) are named by the 60% of them. In Arauco, the top three most salient species were native, *maqui* (*A. chilensis*, S = 0.45), *mutilla* (*U. molinae*, S = 0.44) and *nalca (G. tinctoria*, S = 0.42), plants that were mentioned for more 60% of the surveyed. Among the 15 most salient plants, eight species were exotic in Paredones and four species were exotic in the case of Arauco (Figure 8). Amid the species reported, 38% and 39% of the species were mentioned only by one informant in Paredones and Arauco, respectively.

A.



B.

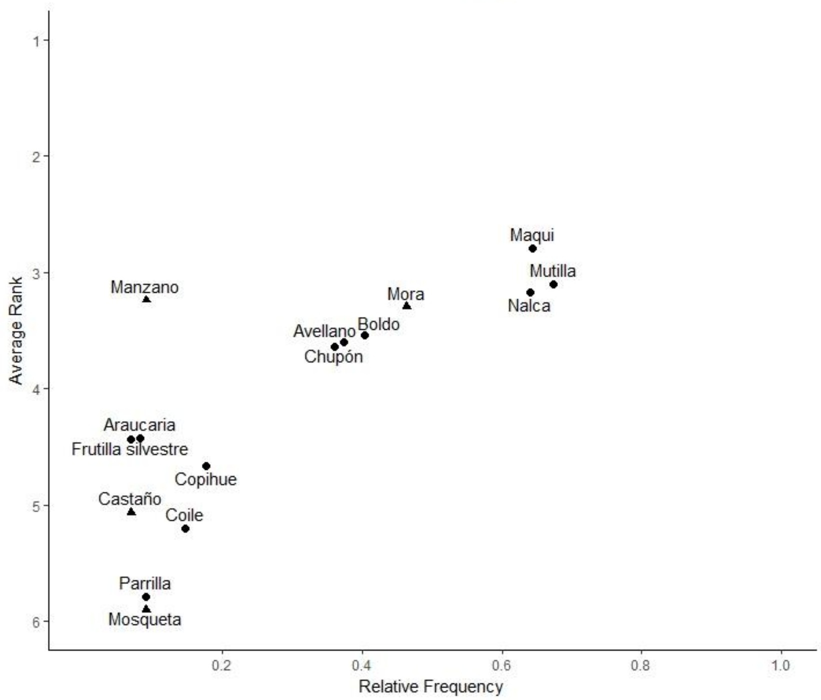


Figure 8. Relative frequency and average position in which the 15 most salient plants were named in Paredones (A) and Arauco (B). Black filled circle represent native species and black filled triangle represents exotic species.

Gathering Distances

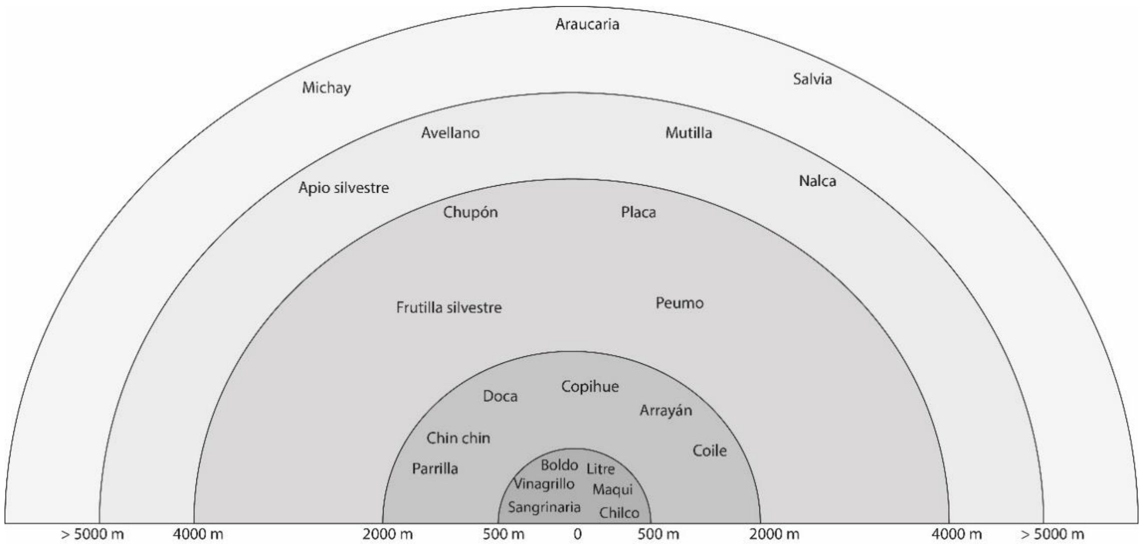
In Paredones 18 native species were gathered (Figure 9) out of the 24 native edible plants reported (Table 3). Species not harvested were those listed as not used in recent times. The salience of the plants collected was negatively correlated to the gathering distances (tau b = -0.17, $p < 0.001$, Kendall rank correlation). Thus, species that are found away from the household were mentioned fewer times and in later positions in the freelists. Among the plants gathered in Paredones, the median gathering distances of the seven representative species were 500 meters (Appendix Figure 4). Amid these plants, the gathering distances of *maqui* (*A. chilensis*) and *boldo* (*P. boldus*), were 275 meters from the household, the shortest gathering distances of plants collected. On the other hand, *chagual* (*Puya spp.*) had the greatest gathering distances, 2.5 kilometers from the houses.

Twenty-three native species were gathered in Arauco (Figure 9) out of the 28 native edible plants reported (Table 5), four species that were not harvested it was because they were not used in recent times and one was obtained through cultivation. Salience of each species with its respective gathering distance was also negatively correlated (tau b = -0.10, $p < 0.001$, Kendall rank correlation). The median gathering distances of those plants that accumulated the 90% of the cumulative salience (Appendix Figure 5) were 2.5 kilometers. Amid these species, the plants sought furthest were *nalca* (*G. tinctoria*), *murta* (*U. molinae*) and *avellano* (*G. avellana*) at 5 kilometres of the household. The plant harvested nearest the houses was *boldo* (*P. boldus*) at 225 meters.

Gathering distances of the most salient exotic species were mainly near the houses of the rural dwellers. The gathering distances of *penca (C. cardunculus), mora (Rubus ulmifolius), manzano (Malus domestica), yuyo (Brassica rapa), membrillo (Cydonia oblonga)* and *mosqueta (Rosa rubiginosa)* were less than 300 meters of the household. Although, *berro* (*Nasturtium officinale*), gathered in Paredones, was harvested at 1.5 kilometres in streams and damp places and *castaño* (*Castanea sativa*), in Arauco, was harvested more than 1 kilometres.

Concerning the gathering patterns in Paredones, the maximum gathering distance was not significantly related to the currently native forest cover (Tau b = 0.018, $p = 0.761$, Kendall rank correlation). In Arauco, the maximum gathering distance was negatively and significantly correlated (Tau b = -0.210, $p < 0.0001$, Kendall rank correlation). Thus, in Arauco persons with less native forests in the surrounding area, they harvested at greater distances (Figure 10).

A.



B.

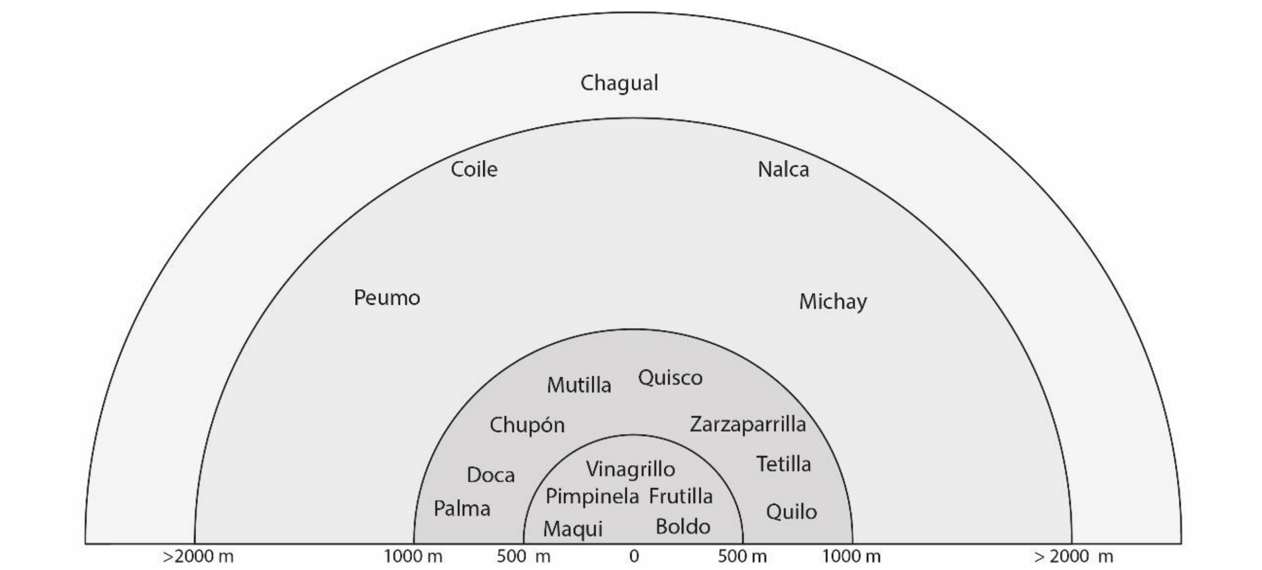


Figure 9. Median gathering distances of native species collected in Paredones (A) and Arauco (B).

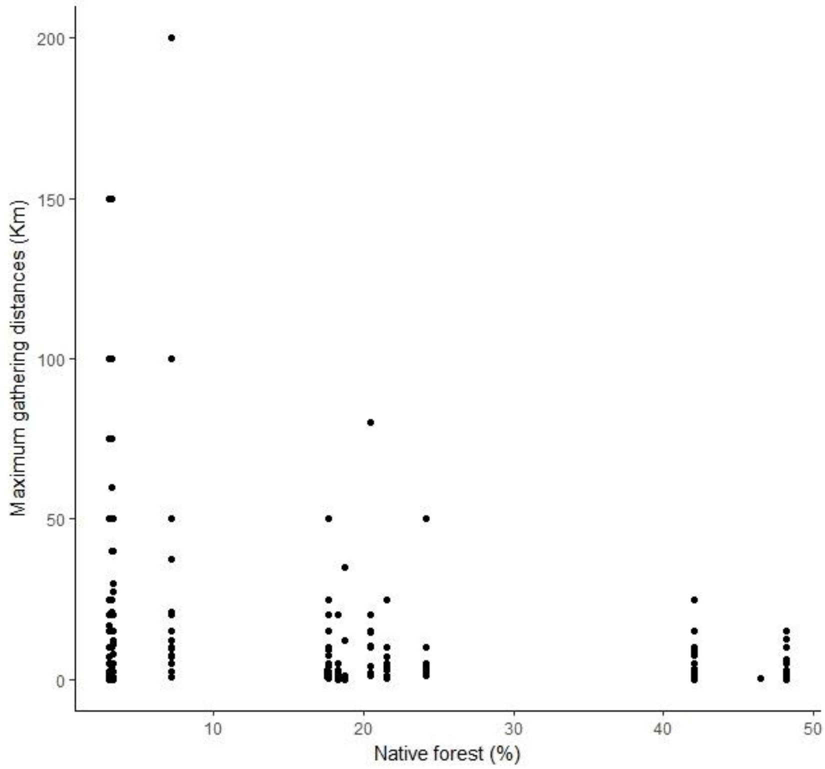


Figure 10. Maximum gathering distance reported as related to current native forest coverage in Arauco.

Replacement Effects

The proportion of native and total species mentioned by informants was positively and significantly associated to both, the cover of native forests available by 1970s (tau b = 0.275, $p < 0.0001$) and the coverage of native forests still available (Tau b = 0.088, $p = 0.013$, Kendall rank correlation).

The replacement rate of native forests had no effects on the knowledge and use of native edible plants (p-value > 0.1). Nevertheless, the number of native plants listed (estimate = 0.011, $p = 0.060$) as well as native plants used (estimate = 0.017, $p = 0.031$) were positively related to the amount of forest cover available by 1970s (Table 6).

Table 6. Results of multivariate analysis between edible plants known and used with explanatory variables.

Variable	Native edible plants known	Native edible plants used
Native forests 1970's	0.011(0.006)*	0.017(0.008)**
Replacement of native forests	-0.001(0.003)	-0.002(0.004)
Education	0.011(0.010)	-0.005(0.011)
Intermediate rural experience	0.207(0.150)	0.204(0.169)
High rural experience	0.265(0.138)*	0.198(0.156)
Age	0.011(0.003)***	0.006(0.003)**
Countryside jobs	0.274(0.066)***	0.325(0.074)***

Note: Coefficient estimates of Poisson GLMM (link = log) and in parenthesis the standard errors.

*,**,*** refer to significant levels at 10%, 5% and 1%, respectively.

Persons with countryside jobs had greater knowledge (estimate = 0.274; $p < 0.0001$) and used more native edible plants (estimate = 0.325, $p < 0.0001$) than person with jobs unrelated to rural activities. Moreover, the knowledge (estimate = 0.011, $p < 0.0001$) and use of edible plants (estimate = 0.006, $p = 0.038$) bore a positively and statistically significant association with age, although low correlation values. Besides, persons with high rural experience who had lived all their life in rural environmental know more edible plants than persons with low rural experience (estimate = 0.265, $p = 0.054$). Full model details are given in the Appendix (Table 7).

DISCUSSION

People worldwide are interacting less with nature (Miller 2005, Pyle 2003, Soga and Gaston 2016), inhabiting biologically impoverished places who offer fewer contacts and limited opportunities to experience nature which coupled with social and cultural changes triggers a growing extinction of experience (Kai et al. 2014; Soga and Gaston 2016; Turner et al. 2004). In the last decades, the natural landscape of south-central Chile has been converted into exotic tree plantations (Miranda et al. 2017). Therefore, rural dwellers of south-central Chile are not exempt from the extinction of experience phenomenon due to the replacement of native forests by monocultures of exotic species.

Interestingly, the rate of recent replacement of native forests per exotic forest plantations does not account for the knowledge and use of native edible plants indicating that knowledge loss occurs at a slower pace than land use change. In fact, the number of native edible plants known and used is explained by the amount of native forests available by 1970s. Hence there seems to be a time lag between forest availability and knowledge, suggesting there is an "extinction-debt" regarding the knowledge of food plants. Secondly, although some species are distributed in streams and damp places, further away from houses, like *coile* (*L. biternate)* and *nalca (G. tinctoria)*, wild plants used are mainly in anthropic areas, near the household. As *maqui (A. chilensis)* and *boldo (P. boldus)*, high salient species in both communes, that are gathered less than 300 meters from de household. Thus, the knowledge and use of these species could remain despite the native forests disappear. Thirdly, the small patches of remaining native forest that are in the vicinity of the rural household could support the current use of wild edible plants, thus maintain the local knowledge on these plants. Moreover, in this landscape mosaic people can move at a greater distance for gather wild plants, which is the case of rural dwellers of Arauco (Figure 10), suggesting the adaptive nature of these local traditions (Reyes-García 2013).

Furthermore, the extinction of experience not only take place when people live in biologically impoverished places but also if there are no significant acts of learning with the environment (Pyle 2003). The assessment of experience with nature has mainly taken place in urban context pointing out to urbanization as the main cause of the extinction of experience (Bendzt et al. 2013; Henriquez 2008; Miller 2005; Neuvonen et al. 2007; Samways 2007; Turner et al. 2004; Zhang et al. 2004). Nevertheless, our results support that the knowledge in rural dwellers is also heterogeneous. Although these inhabitants can live in the same places, they have a different degree of knowledge of wild edible plants. Thus, the mere presence of the food plants does not imply an associated knowledge since it is necessary a way in which nature is actively experienced (Barraza and Cuarón 2004), to have and maintain wild food plants knowledge. In our case of study, countryside jobs are crucial to the knowledge and use of edible plants (Table 6). Persons with rural jobs with daily and constant interaction with nature, have greater knowledge and use more native edible plants than people with jobs unrelated to countryside activities.

Women have a central role in the knowledge and use of wild plants, and even they are fundamental to safeguarding, conserve and transmits this cultural heritage to new generations (Belahsen et al. 2016; CBD 1992; Howard 2003; Sommasang et al. 1998). Nevertheless, our results show that 77% of the women surveyed perform jobs unrelated to countryside activities, the majority being housewives (68%). As a consequence, they domain fewer numbers of edible plants than men, who also have larger ranges of movement exposing them to more opportunities to gather plants (Duque 2008; Kujawska and Łuczaj 2015) and a constant experience of nature due to the gender division of labour (Agarwal 1992; Joekes 1995).

Consequences of human activities linked with the land use change are the establishment of exotic species (McKinney and Lockwood 1999; Sounder et al. 1991). In Chile, there is an invasion of exotic plants associated with *Pinus radiata* plantation (San Martín and Donoso 1995). In fact, there is a higher richness of exotic plants in forest fragments and the exotic tree plantation than in native continuous forest (Becerra and Simonetti 2013). Exotic plants might endanger knowledge of native plants through the displacement of their use by exotic plants, which are more widespread and abundant (Hernández 2008). This phenomenon is indeed expressed in the high salience of exotic species in the cultural domain of edible plants (Figure 8) and the numerous exotic plants listed (Figure 7), particularly in Paredones, a locality which already by the 1970s native forests have been largely replaced. Exotic plants mentioned in Paredones were all growing near houses and are usually harvested in disturbed areas like open fields, along the rural road, plantation edges, less than 300 meters from their houses (see also Ladio and Lozada 2004).

Biodiversity provides ecosystem services that contribute to food security and associated human welfare (MA 2005), either through the provision of wild food or the utilization of these resources by rural communities to earn income, either as fresh fruits, underground organs, leaves, stems, as well as elaborated products of wild food plants (Łuczaj et al. 2012; Miele and Murdoch 2002; Richardson 2010; Sujarwo et al. 2014). As do occur with *avellanas* (*G. avellana*) in these localities (Zorondo-Rodríguez et al. in press). Therefore, the management of native forests ought to integrate biological conservation targets as well as the needs of local people (Berkes and Davidson-Hunt 2006), which could be the case of *Jubaea chilensis* and *Echinopsis chiloensis,* species regarded as vulnerable but that are used as food source in Paredones (MMA 2012).

In brief, the present study assesses the relationship between land use change with edible plant knowledge and use by rural dwellers of the south-central Chile in forest plantations territories. When the extinction of experience process occurs is not the only condition when the plants disappear from the surrounding area since this process must come along with the disappearance of an active act of learned and experience nature. The current work highlights the important role of rural jobs on the conservation of local knowledge and use of native edible plants. Besides, we draw attention to the current situation of women in rural households, which are socially hampered to know and interact with nature due to the gender division of labour. We characterize the plants currently used and gathered in rural dwellers in territories affected by the forestry expansion. It is interesting to note the long distances that people are willing to travel for the aim of harvest edible plants. Finally, since the knowledge is maintaining despite the recent replacement of native forests regarding the lag between cultural and landscapes changes, we surmise there is still time to rescue, value and increase native edible plant use. Greater knowledge of these plants would improve the rural economies and the reception toward future conservation and ecological restoration plans (Soga and Gaston 2016; Zhang et al. 2014). Our findings should encourage the policymakers to focuses on people with countryside jobs to rescue this knowledge, and cultural restoration plans must address to women and youths. We propose to generate instances of cultural diffusion to share the local knowledge on native edible plants, with an active participation of local communities and scientific stakeholders.

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APPENDICES

Appendix 1. Survey Guideline.

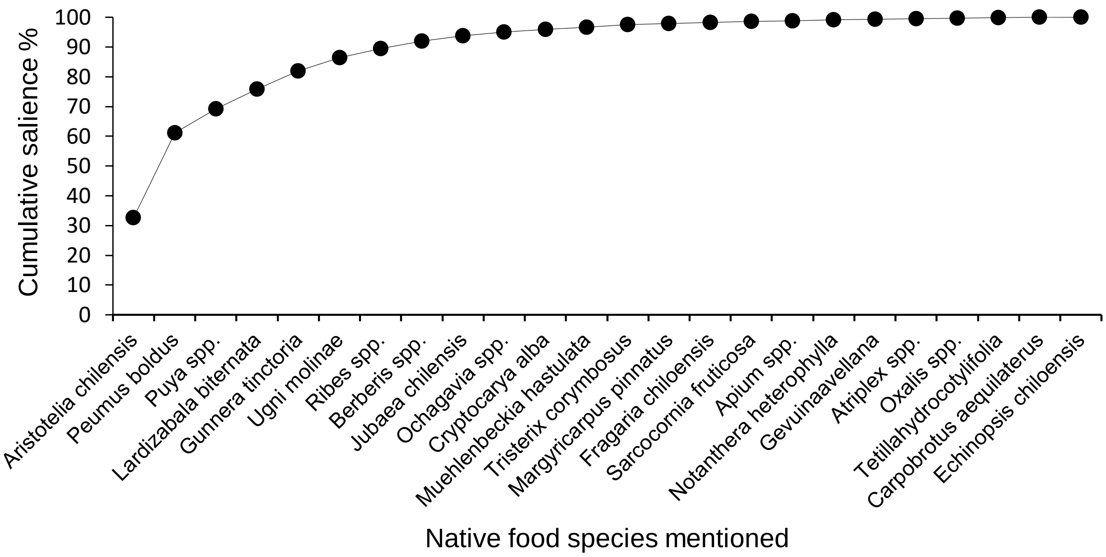
1) What wild plants, meaning that they grow alone, do you know that are used as food?

2) Of the ones you named, which ones have you or your family used over the last year?

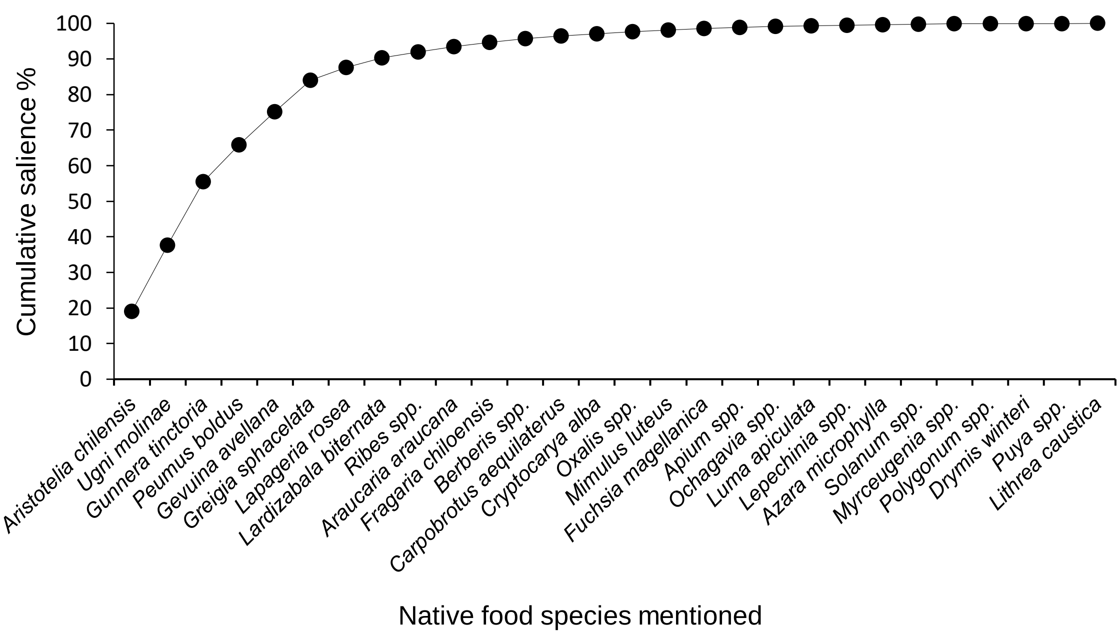
3) How do you get the plants you used last year?

3.1) (If they gathered them) Where do you gather them from? How much distance is it that place from your home?

3.2) (If they do not gathered them) Where do you get them



Appendix Figure 4. Cumulative relative salience of native food species in Paredones. We considered the gathering distances of *Aristotelia chilensis, Peumus boldus, Puya spp., Lardizabala biternata, Gunnera tinctoria, Ugni molinae, Ribes spp.* to establish a gathering area.



Appendix Figure 5. Cumulative relative salience of native food species in Arauco. We considered the gathering distances of *Aristotelia chilensis, Gunnera tinctoria, Ugni molinae, Peumus boldus, Gevuina avellana, Greigia sphacelata* and *Lapageria rosea* to establish a gathering area.

Appendix Table 2. Exotic species reported in Paredones, 57 species in total, ordered by Smith's Salience Index*.

Spanish name	**Scientific name**	**Salience index**	**Absolute frequency**
Penca	*Cynara cardunculus*	0.2280	62
Mora, Zarzamora	*Rubus ulmifolius*	0.1922	72
Manzano	*Malus domestica*	0.0796	20
Yuyo	*Brassica rapa*	0.0740	19
Berro	*Nasturtium officinale*	0.0564	15
Membrillo	*Cydonia oblonga*	0.0429	13
Ajo, Ajo Silvestre	*Allium vineale*	0.0423	11
Peral	*Pyrus communis*	0.0370	12
Acelga	*Beta vulgaris*	0.0331	8
Ciruelo	*Prunus domestica*	0.0321	11
Durazno	*Prunus persica*	0.0308	9
Mosqueta, Rosa Mosqueta	*Rosa rubiginosa*	0.0272	11
Limón	*Citrus limon*	0.0240	7
Rábano	*Raphanus spp.*	0.0235	7
Tuna	*Opuntiaficus indica*	0.0164	5
Naranjo	*Citrus sinensis*	0.0158	4
Laurel	*Laurus nobilis*	0.0147	4
Romero Castilla, Romero	*Rosmarinus officinalis*	0.0138	4
Romaza	*Rumex spp.*	0.0138	3
Alcachofa	*Cynara scolymus*	0.0123	3
Ajo Chilote, Ajo Perro, Ajo Porrón	*Allium ampeloprasum*	0.0121	4
Uva, Parra	*Vitis vinifera*	0.0107	4
Higuera	*Ficus carica*	0.0082	5
Guindo	*Prunus cerasus*	0.0066	3
Lechuga, Lechugin	*Lactuca serriola*	0.0063	2
Eucalipto	*Eucalyptus spp.*	0.0052	1
Manzanilla	*Matricaria recutita*	0.0052	1
Orégano	*Origanum vulgare*	0.0052	1
Fruto de oro	*Physalis peruviana*	0.0052	1
Arándano	*Vaccinium myrtillus*	0.0052	1
Cardo Burro, Cardo Santo,	*Silybum marianum*	0.0051	2

Tallo burro			
Alfilerillo	*Erodium moschatum*	0.0048	1
Pino, Pino de Comer, Pinas	*Pinus pinea*	0.0044	3
Diente de León, Lechuguilla	*Taraxacum officinale*	0.0043	2
Ciboulette	*Allium schoenoprasum*	0.0043	1
Llantén	*Plantago spp.*	0.0043	1
Damasco	*Prunus armeniaca*	0.0042	2
Caléndulas	*Calendula officinalis*	0.0040	1
Nogal	*Juglans regia*	0.0038	2
Menta	*Mentha suaveolens*	0.0038	2
Níspero	*Eriobotrya japonica*	0.0036	1
Quinua	*Chenopodium quinoa*	0.0035	1
Hinojo	*Foeniculum vulgare*	0.0035	1
Olivo	*Olea europaea*	0.0030	3
Cedrón	*Aloysia citriodora*	0.0026	2
Melón	*Cucumis melo*	0.0026	1
Malva	*Malva sylvestris*	0.0017	1
Grosella	*Ribes rubrum*	0.0017	1
Castaño	*Castanea spp.*	0.0013	1
Morrón	*Rubus spp.*	0.0013	1
Salvia	*Salvia officinalis*	0.0013	1
Poleo	*Mentha pulegium*	0.0010	1
Cebolla	*Allium cepa*	0.0009	1
Zanahoria	*Daucus carota*	0.0009	1
Leopoldo, Miosporo	*Myoporum laetum*	0.0009	1
Aloe vera	*Aloe vera*	0.0006	1
Linaza	*Linum usitatissimum*	0.0006	1

* Smith's Salience Index was carried out at the commune level with native and exotic plants.

Appendix Table 4. Exotic species reported in Arauco, 36 in total, ordered by Smith´s Salience Index*.

Spanish name	**Scientific name**	**Salience index**	**Absolute frequency**
Mora, Zarzamora	*Rubus ulmifolius*	0.2946	108
Manzano	*Malus domestica*	0.0585	21
Mosqueta, Rosa Mosqueta	*Rosa rubiginosa*	0.0345	21
Laurel	*Laurus nobilis*	0.0282	9
Castaño	*Castanea spp.*	0.0278	16
Ciruelo	*Prunus domestica*	0.0252	11
Berro	*Nasturtium officinale*	0.0212	8
Yuyo	*Brassica rapa*	0.0150	4
Durazno	*Prunus persica*	0.0132	5
Acelga	*Beta vulgaris*	0.0129	3
Ajo, Ajo Silvestre	*Allium vineale*	0.0116	3
Guindo	*Prunus cerasus*	0.0100	6
Romaza	*Rumex spp.*	0.0095	3
Peral	*Pyrus communis*	0.0084	4
Rábano	*Raphanus spp.*	0.0074	3
Perejil	*Petroselinum crispum*	0.0064	2
Penca	*Cynara cardunculus*	0.0062	6
Frambuesa	*Rubus idaeus*	0.0049	2
Cilantro	*Coriandrum sativum*	0.0043	1
Hierba Buena	*Mentha spicata*	0.0043	1
Ortiga	*Urtica urens*	0.0043	1
Poleo	*Mentha pulegium*	0.0041	1
Diente de León	*Taraxacum officinale*	0.0039	4
Cebollino	*Allium schoenoprasum*	0.0037	1
Cerezo	*Cerasus spp.*	0.0029	1
Pino	*Pinus pinea*	0.0025	1
Níspero	*Eriobotrya japonica*	0.0024	1
Cardo Blanco	*Silybum marianum*	0.0023	1
Golden Berry	*Physalis peruviana*	0.0021	1
Arándano	*Vaccinium myrtillus*	0.0017	1

Membrillo	*Cydonia oblonga*	0.0014	1
Damasco	*Prunus armeniaca*	0.0011	1
Romero Castilla, Romero	*Rosmarinus officinalis*	0.0011	1
Encino	*Quercus ilex*	0.0009	1
Uva, Parra	*Vitis vinifera*	0.0008	1
Chicoria	*Cichorium intybus*	0.0005	1

* Smith's Salience Index was carried out at the commune level with native and exotic plants.

Appendix Table 7. Full model details and results of the generalised linear mixed model for native edible plants known (A) and edible plants used (B) with the explanatory variable of lands covers and sociocultural. The hamlets where the informants were surveyed were included as random effects to account for non-independence answers from the interviewees from the same hamlets and to avoid collinearity in our model, we used a threshold correlation coefficient of $|r| \geq 0.7$ in the explanatory variable. We proved the effects of the interaction between rural experience and native forest 1970s in the plants' knowledge, resulting in a non-significant relationship (p-value = 0.29). Thus, we excluded this interaction in our final model.

A. Edible plants known

Generalized linear mixed model fit by maximum likelihood (Adaptive Gauss-Hermite Quadrature, nAGQ = 100) [glmerMod]

Family: poisson (log)

Formula: native known ~ bn70 + replacement bn + education + rural experience + age + job + (1 | hamlet)

Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 1e+05))

AIC	BIC	logLik	deviance	df.resid
472.9	506.8	-227.4	454.9	309

Random effects:

Groups	Name	Variance	Std.Dev.
hamlet	(Intercept)	0.06725	0.2593

Number of obs: 318, groups: localidad, 16

Fixed effects	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	0.043975	0.271900	0.162	0.8715
Native forests 1970's	0.011060	0.005875	1.883	0.0598*
Replacement of native forests	-0.001455	0.003208	-0.454	0.6501
Education	0.010683	0.009668	1.105	0.2692
Intermediate rural experience	0.207145	0.149964	1.381	0.1672
High rural experience	0.265488	0.137714	1.928	0.0539*
Age	0.010984	0.002507	4.381	1.18e-05***
Countryside jobs	0.274083	0.066113	4.146	3.39e-05***

*,**,*** refer to significant levels at 10%, 5% and 1%, respectively

B. Edible plants used

Generalized linear mixed model fit by maximum likelihood (Adaptive Gauss-Hermite Quadrature, nAGQ = 100) [glmerMod]

Family: poisson (log)

Formula: native used ~ bn70 + replacement bn + education + rural experience + age + job + (1 | hamlet)

Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 1e+05))

AIC	BIC	logLik	deviance	df.resid
487.0	520.9	-234.5	469.0	309

Random effects:

Groups	Name	Variance	Std.Dev.
hamlet	(Intercept)	0.1334	0.3652

Number of obs: 318, groups: localidad, 16

Fixed effects	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	0.137797	0.313439	0.440	0.6602
Native forests 1970's	0.016980	0.007879	2.155	0.0312**
Replacement of native forests	-0.001614	0.003678	-0.439	0.6607
Education	0.203676	0.169340	1.203	0.2291
Intermediate rural experience	0.197599	0.156355	1.264	0.2063
High rural experience	-0.005367	0.010917	-0.492	0.6230
Age	0.005825	0.002814	2.070	0.0384**
Countryside jobs	0.325366	0.073861	4.405	1.06e-05***

*,**,*** refer to significant levels at 10%, 5% and 1%, respectively