Project Title: Assessment of Ecosystem Services in the Coyhaique Watershed, Chilean Patagonia. Recommendations for Sustainable Development.

University of California, Davis
M.S. International Agricultural Development
Capstone Report

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1. EXECUTIVE SUMMARY

The Aysén region is one of the most remote regions of the Chilean territory and has one of the largest areas of native forests in the country. As a result of the application of various public policies and a lack of knowledge about natural resources, many of these ecosystems are in a growing state of degradation, limiting their inhabitants in options for sustainable development. The following document focuses on a diagnosis of the current state of the ecosystem services present in the Coyhaique river basin, precisely where they are located, who benefits from them, and who is making relevant decisions in regard to their use. A field campaign was carried out in July-September 2018 to collect technical information on the natural resources, interview authorities, and survey the inhabitants of the basin. The aim was to understand their perception of ecosystem services, their uses, what challenges the natural resources face, and how this affects their development perspectives. As part of the results, the residents identified the quality and quantity of water, its influence on air quality, and the usefulness of forests in the production of firewood as the major ecosystem services provided by the forests in the basin. The principal challenge was the abandonment of the Coyhaique River.

The recommendations of this report are to conduct future studies, quantification of the current state of natural resources in the basin (terrestrial and aquatic ecosystems), and the creation of maps aiming to remark and organize the multiple uses in the watershed. Decision makers currently have outdated or insufficient information from which they construct their development strategies.

2. BACKGROUND

The Aysén region is known for its invaluable scenic value and the state of conservation of its natural resources. The region depends economically on activities such as aquaculture, forestry, livestock, and mining. Therefore, forestry, livestock, and recently, tourism, are activities of great regional influence because the participation is democratic and an essential part of the Patagonian culture. However, it does not guarantee the sustainability of their use. It is widely documented that in developing economies, development is based on the use of available natural resources.

What are the available natural resources? Where are they located? What is their state and who are the people whose livelihoods depend directly on their use? The objective of the present Capstone study is to identify and evaluate the location of the natural resources in the Coyhaique river basin. Under the framework of Ecosystem Services (ES), this study aims to understand how public policies have affected the state of the ES and the governability of natural resources in the basin.

The hypotheses are: H1: The history of colonization and land use of the Aysén region is reflected in the current condition of natural resources; H2: Rural people in Patagonia who depend on their use of natural resources would not use sustainable land use practices during the cold season (fall-winter-spring) in order to subsist; H3: Areas in the basin with old-growth forest present a greater variety of ecosystem services in comparison with areas without old-growth forest; and H4: Watersheds with sustainable use of their natural resources (Forest-livestock) have higher ES, and this could result in higher economic values and alternative uses.

The specific objectives are: a) describe the history of land use of the Coyhaique basin; b) identify the location and availability of each ES in the basin and their direct users; c) review and collect information in terms of carbon storage (wood or firewood production), freshwater availability (quantity and quality), productivity of grazing (vegetation composition), biodiversity (vegetation and animal composition) and tourism activity to describe the present condition of the basin; and d) recommend strategies for sustainable use of natural resources focused on the ecosystem services provided by the temperate forest.

The Coyhaique basin is an excellent example of the transformation of land use throughout the history of the region, and also a place where problems such as air quality, water shortage, soil erosion, and urbanization are affecting the quality of life of its inhabitants. This capstone is laying a foundation for a more exhaustive study under a Ph.D. program, which aims to deepen the cultural and political-economic influences under different scenarios of climate change in some basins in the region of Aysén, as well as an analysis of the state of the natural resources (water, forest, agriculture, biodiversity and tourism).

The information used in this document comes from different bibliographic sources such as scientific articles, technical reports, and databases. In July-September 2018 a field campaign was carried out to verify the information and to complement it with interviews and surveys of relevant figures from the public and/or private sector, and residents. The questions included in the survey were based on CASEN 2017, 2015; Zaragola, et al, 2014; MMAmb 2015. Before conducting interviews and surveys, the protocols and questions were approved by the Institutional Review Board office, UC Davis (1280093-1), and Centro de Estudios de Ecosistemas de la Patagonia, Chile.

2.1 General description of the Aysén Region

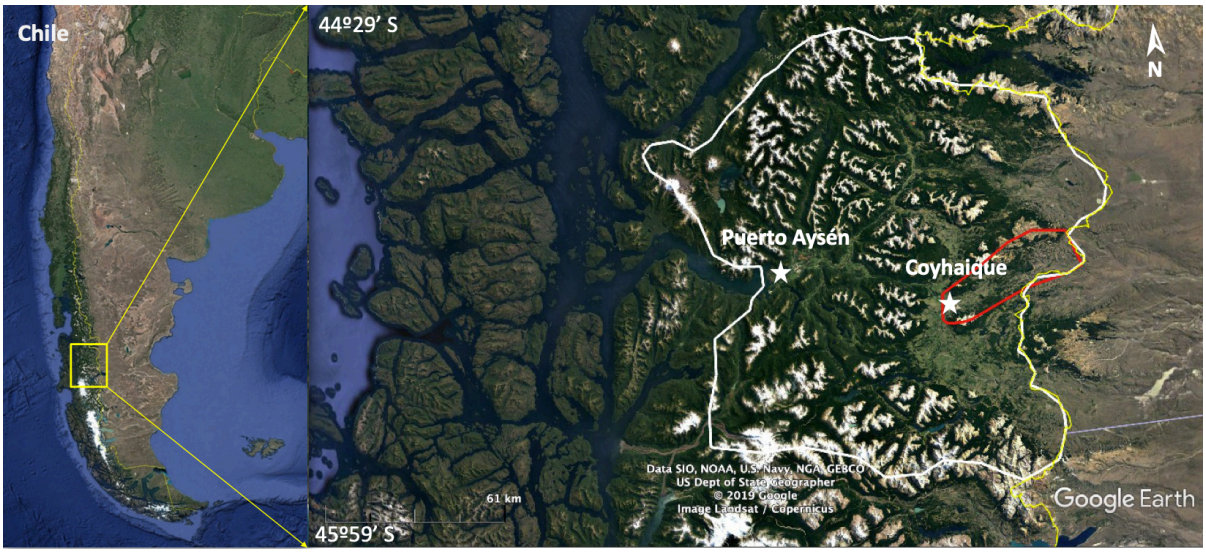

Figure 1. The Aysén region (39°- 46° S) presents a diverse range of ecosystems expressed in a latitudinal gradient as well as meridional changes, in a short distance coexist temperate rain forest in the fjord lands, deciduous *Nothofagus* forest, scrublands and steppe in the east (Donoso, 1981; Veblen et al., 1992; Gajardo, 1994). The Aysén river basin (white polygon) is located on the Andes mountain range, the morphology is segmented, characterized by snow-melting erosion, which connects the various river basins by river channels (MOP-DGA, 2004). The climate of the Aysén River basin has a humid oceanic climate with low temperatures in the coastal zone and abundant rainfall in the coastal zone (Puerto Aysén 2,940 mm per year), central area is influenced by the cold steppe (Coyhaique 1,385 mm). The soils of the Aysén river basin (red polygon) are volcanic, coarse in texture (sandy loam to sandy), stratified, and with low levels of fertility and moisture retention (IREN-CORFO, 1979).

The Land Capability Class (LCC) is an index determined by the depth, texture, slope, and degree of past erosion. This index establishes the most suitable intensive uses for a territory avoiding erosion. The soils of the Region of Aysén are classified as III to VIII, due to restrictions for their use (Stolpe, 2012; SERPLAC, 2005).

Economically, the Aysén region is considered a livestock region, although this activity is not relevant in the regional GDP. According to the Central Bank (2016), the region depends on fishing activity (23.76%), public administration (15.25%), construction (16%), and the agricultural and forestry sector only represents 1.79%. The livestock activity in the region has a production of 7.9% (304,936 heads) of sheep production in Chile (ODEPA, 2016), and the province of Coyhaique concentrates 53% of regional bovine production. Tourism is an increased activity due to the quality of the landscape, natural, and cultural resources (PER Turismo 2017). In the year 2015-2016, there was an increase of 20% of visitors, among their main activities were fly fishing, driving the Austral road, and adventure tourism activities (PER Turismo 2017).

In comparison with other territories of Chile, the history of settlement in Patagonia is recent, and influenced by government policies that pursued the sovereignty of Chilean settlements, alongside Argentinians. One of the policies stated that every Chilean could reclaim land in Patagonia if they demonstrated use of it (Sanhueza et al., 2001). As a result, fire was considered an agricultural practice, which, in combination with climate conditions (warmer and drier years), caused massive fires inland in the 1950's (Mundo, et al., 2017; Holz et al., 2012). Wind, rain and drought produced severe erosion in the soils after fire events, that, in conjunction with grazing uses and new environmental conditions, made it difficult for the forest to regenerate (Kitzberger et al., 2016).

The Aysén region has one of the lowest population densities in the Chilean territory with 0.9p/km2 (INE, 2019). The population is concentrated in urban areas (79.6%), being the main cities Coyhaique, Puerto Aysén, Chile Chico, and Cochrane (Census, 2017). The multidimensional poverty indices (CASEN, 2017) identify the region with low access to education, health, and poor

connectivity with the rest of the territory. The difficulty of accessing these services favors forced-regional-migration to urban centers. Due to regional isolation, the Chilean government permanently encourages development through state subsidies in all economic sectors. However, the low connectivity with the rest of the territory and regional climate make it difficult for ventures to remain in business. Rural tourism programs, driven by the Ministry of Agriculture and Ministry of Economy, have been an alternative for diversification of economic activities, especially in rural communities.

2.2 Ecosystem Services (ES)

The Millennium Ecosystem Assessment (MEA, 2005) defines ecosystem services (ES) as the benefits that people obtain from ecosystems. It classifies and evaluates them as Provision, Regulation, Cultural, and Support services (Figure 2). The economic evaluation of these is based on principles of neoclassical economics, assuming that people will tend to maximize profit, and it is the market (or supply) that regulates the value of the service. However, it is also assumed that the market will lead to sustainability and equity in use (Overton et al., 2013). One of the methods for economic valuation is the use of Multicriteria Analysis (MCA), which categorizes different variables by weight through various techniques and designate a monetary value. The result can be used as a tool to visualize the effects of actions or policies on the Wellbeing of people and future generations (TEEB, 2010). However, not all ecosystem services have a market value. Although there are advances in their evaluation, their complexity implies that economic evaluation should be used as a guideline tool, not as a condition for taking concrete actions (TEEB, 2011). Some authors debate this vision and incorporate the evaluation of wellbeing based on the

principles of subsistence, protection, affection, understanding, participation, leisure, creation, identity and freedom (Max-neff, 1991; Overton et al., 2013; Roberts et al., 2015; Zoe et al., 2018).

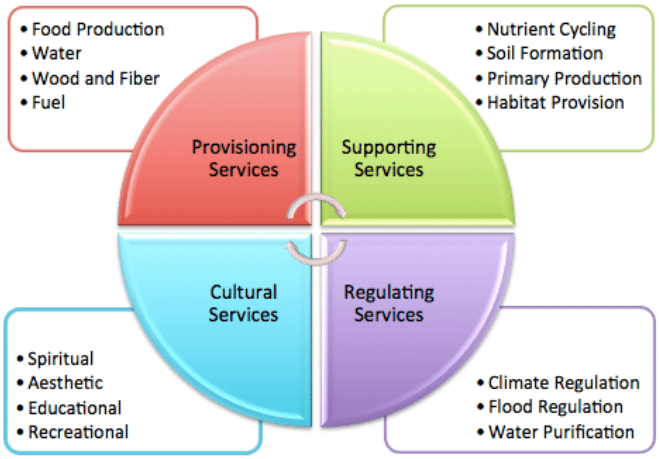

Figure 2: Millennium Ecosystem Assessment, 2005 (Overton et al, 2013).

3. PRELIMINARY RESULTS

3. 1 Coyhaique historical context of land use

The first Ayseninos arrived in the region about 11,000 A.P. through the eastern part of the territory, in which the retreat of the late Pleistocene glaciers was earlier than in the interior areas of the region (Martinic 2005). The landscape presumably were open forests of Ñirre (*N. antárctica*), Lenga (*N. pumilio*) in combination with coironal (forest-steppe transition) (Martinic, 2005). This open forest, together with the opening of the Pampas (steppe) made this area an ideal place for settlers of nomadic hunter-gatherers of Guanaco (Martinic 2005). Archaeological studies in the region are still recent, and the presence of old settlements in the Coyhaique Alto area is unknown (Martinic, 2005; Borrero 2009; Velazquez et al., 2006; Mena et al., 2000). In 1940 the first ethnography study identified the nomadic indigenous group that inhabited the steppe and some interior valleys, the Tèushenkenk or Tehuelches (Martinic, 2005). In 1870, the

Argentine government sent military troops to exterminate the indigenous populations and legally claim Chilean territory for the expansion of the Argentine ranches. Avoiding this genocide, some indigenous groups took refuge in Chilean valleys such as Coyhaique Alto and Bajo (Martinic 2005). It is in this period, and under the pressure of Argentina, that Chile begins a process of modern colonization based on the expansion of livestock ranches, through the concession of vast territories. These concessions brought not only sovereignty but also a new development system based on the exploitation of natural resources and fire.

3.1.1 Hypothesis, objectives and Methods

Hypothesis: The history of colonization and land use of the Aysén region is reflected in the current condition of natural resources.

Objective: Describe the history of land use of the Coyhaique basin.

Methods: The synthesis of the history of the use of natural resources in Aysén is based on literature review, interviews with public agencies, and conversation with some settlers, who are part of the modern history of the territory.

3.1.2 Synthesis

The use of fire is part of Aysen's culture and was used to open valleys of impenetrable vegetation, to clean land and create grasslands for animals, and to heat and cook at homes. Between 1920 and 1956, approximately 5,000,000 ha were burn in the region (Holz et al., 2011, CONAF 2016), which initially had the opening of territories for colonization. These fires, in combination with dry years and wind, spread out of control over the territory. Then it was rain,

wind, and the geomorphological characteristics that led to the intense erosion of the Aysén-territory. In 1974, the government legislated the Law of Forestry Development (DL 701) that subsidizes the planting of exotic forestry species, which in the case of Aysén, was used to reforest and stop erosion in some territories. However, again the regional isolation and the lack of roads did not allow these plantations to have an economic return, so many have been left without cultural management and with initial densities (3900 trees/ha), increasing the current risk of new forest fire (figure 3).

At present, a few first settlers are still alive and witnessed the natural wealth and the adventures of settlements in Aysén. An example is the Pantanalli family, who arrived in 1920 through the Simpson river valley, and their poetry (a form of folkloric communication), recounts the conditions of the time:

"They say that in the valley The Moon are many settlers, but Lucho and Delfi are one of the best. If you want to check, someday go for a walk, you will see that you will meet with special affection. Lucho is going to prepare a golden lamb; Delfi some matecitos (tea), and good conversation. If you want to work, you can be hired there, because Lucho hired up to three men to make firewood until spring."

Pantanalli, 101 years. Colonizer of the Aysén Valley.

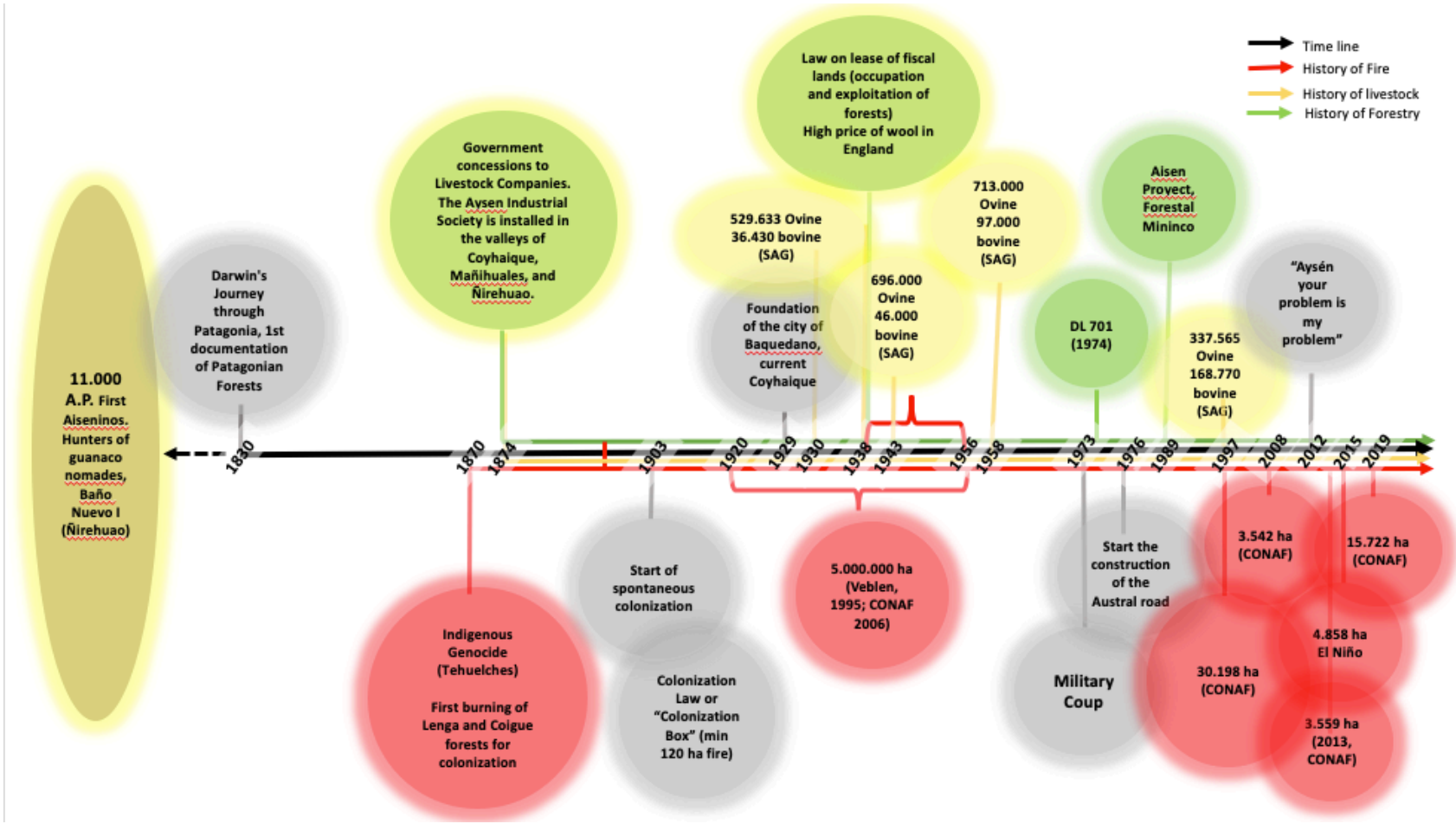

Figure 3. Synthesis of relevant events in the history of use and current condition of natural resources in the Aysén region

3.1.3 Recommendations for actions

Thus, there is need to describe Historic Analysis and how the historical policies have determined the current use of natural resources.

3.2. Ecosystem Services/Physical context of the Coyhaique basin

The Coyhaique River Basin is an excellent example of the possible bioclimatic ecosystems and transitions found in the region. The Coyhaique river has its origin in the Patagonian steppe and culminates in the confluence with the Simpson river, in the zone of temperate deciduous *Nothofagus* forests (Veblen, 1992). The Coyhaique river has a mixed flow regime, where the flow caused by snowmelt is considerably higher than that caused by precipitation (Hepp, et al 2018) and the climate is influenced by the cold steppe, with a mean precipitation of 1,385 mm. The Coyhaique river basin has a Land Capability class IV, corresponding to terraces with gentle or flat slopes with slight drainage problems, and it is recommended that they be used for occasional crops (with conservation measures) in rotation with grasslands (Stolpe, 2012; SERPLAC, 2005). The soils of the Coyhaique basin have a transition from Mollisols in the steppe to Andisols after the confluence with the Simpson river (Stolpe, 2012). The soils in the Coyhaique basin have a texture moderately coarse (sandy loam) to moderately fine (clay loam, silty loam, or sandy clay loam) with medium permeability and a moderate degree of erosion (IREN-CORFO 1979).

3.2.1 Hypothesis, objectives and Methods

Hypothesis

H1: Areas in the basin, with old-growth forest presents a greater variety of ecosystem services in comparison with areas without old-growth forest.

H2: Watersheds with sustainable use of their natural resources (Forest-livestock) have higher Ecosystem services, and this could result in higher economic values and alternative uses.

Objectives:

- Review and collect information in terms of carbon storage (wood or firewood production), freshwater availability (quantity and quality), productivity of grazing (carrying capacity, vegetation composition), biodiversity (vegetation and animal composition), and tourism activity, to describe the present condition of the basin.

- Identifying the Ecosystem Services and the potential for conservation and associated risk.

Methods: When carrying out an ecoclimatic classification of the Aysén region, there is little openly available information. The information used in this physical description corresponds to the one used by the Agricultural and Livestock Service (Silva, 2017) and the National Institute of Agricultural Innovation (Hepp et al., 2018) for the Aysén region.

A practical zoning of the basin was carried out, taking into consideration: the different uses of the land, type of soils, eco-climatic classification, size of the properties, accesses, and development potentials. According to these characteristics, three zones are distinguished: Upper zone (Coyhaique Alto to Puente Las Bandurrias), intermediate zone (Puente Las Bandurrias to Tejas Verdes), and Lower zone (Tejas Verdes to the confluence with the Simpson River). The biophysical characteristics of the three zones are summarized in table 1.

Table 1. Summary of the biophysical characteristics of the Coyhaique basin by zone.

	Zone 1: Coyhaique Alto – Las Bandurrias	Zone 2: Las Bandurrias – Tejas Verdes	Zone 3: Tejas Verdes – Confluence with the Simpson river
Climate	"Cold Steppe with a dry summer of Western Patagonia" (Bsk'c, SAG 2006, Silva 2017)(Csc, Köppen, 1918). With a mean precipitation of 570 - 600 mm, mean temperature of 7 – 8.9°C, and with winds that sometimes exceed 100 km/hr, which generates a water deficit of up to 5 months and intense wind erosion (INIA; Hepp et al., 2018). (Appendix 1).	"Temperate intermediate humid ecoregion" (Cfb, Köppen) "Mediterranean Climate with hot summers" (Hepp, 2018). With a mean precipitation of 900 mm and a mean temperature of 7.8°C (Appendix 1).	"Temperate intermediate humid ecoregion" (Cfb, Köppen) "Mediterranean Climate with hot summers" (Hepp, 2018). With a mean precipitation of 900 mm and a mean temperature of 7.8°C (Appendix 1).
Geomorphology and Landscape	The dominant landscape are wide plains with hills of morrenic origin and rocky conglomerates remaining from glacial activity (IREN, 1979). Vast plateaus are adjacent to the border with Argentina, where numerous river basins originate (SAG, 2006). The main river course is the Coyhaique River, and together with its tributaries, they cross the pampas landscape with slow flows, and twisted courses that give rise to abandoned meanders, forming mallines and wet grasslands (IREN, 1979).	Typical landscape of the central valley of Aysen, which characterized by narrow intermontane valleys (IREN, 1979). The Coyhaique river is narrow in closed valleys surrounded by mountains with steep slopes (SAG, 2006).	Typical landscape of the central valley of Aysen, which characterized by narrow intermontane valleys (IREN, 1979). The Coyhaique river is narrow in closed valleys surrounded by mountains with steep slopes (SAG, 2006).
Soils	The texture moderately coarse (sandy loam) to moderately fine (clay loam, silty loam, or sandy clay loam) with medium permeability and a moderate degree of erosion (IREN-CORFO 1979).	The texture moderately coarse (sandy loam) to moderately fine (clay loam, silty loam, or sandy clay loam) with medium permeability and a moderate degree of erosion (IREN-CORFO 1979).	The texture moderately coarse (sandy loam) to moderately fine (clay loam, silty loam, or sandy clay loam) with medium permeability and a moderate degree of erosion (IREN-CORFO 1979).
Vegetation	"Mediterranean-temperate steppe of *Festuca pallescens* and *Mulinum*" (Piscoff, 2015) and "temperate arboreal schubland of *Nothofagus antactica*". Other characteristic species of this area are Green Mata (*Chiliotrichicum diffusum*), Pingo pingo (*Ephedra frustillata*), White Coiron (*Festuca pallescens*) and Foxtail (*Hordeum comosum*) (SAG, 2006)	Aysen deciduous forest (Gajardo, 1997) or temperate Andean deciduous forest of *Nothofagus pumilio* and *Berberis sp* (Piscoff, 2005). This zone is a transition between the forests of the Valdivian jungle and the Patagonian Andean forests, where the Lenga forest type (*N. pumilio*) dominates with the participation of Coigue (*Nothofagus dombeyi*). There is a dominance of anthropic grasslands based on white, pink clover and clew grass, which are degraded to grasslands of Honey grass, pig grass, pimpinela and dandelion (SAG, 2006).	Aysen deciduous forest (Gajardo, 1997) or temperate Andean deciduous forest of *Nothofagus pumilio* and *Berberis sp* (Piscoff, 2005). This zone is a transition between the forests of the Valdivian jungle and the Patagonian Andean forests, where the Lenga forest type (*N. pumilio*) dominates with the participation of Coigue (*Nothofagus dombeyi*). There is a dominance of anthropic grasslands based on white, pink clover and clew grass, which are degraded to grasslands of Honey grass, pig grass, pimpinela and dandelion (SAG, 2006)
Wildlife	Ñandú, Flamenco, Puma, Zorro culpeo, Aguila, Aguilucho, Guanaco, Quirquincho (SAG, 2006).	Quirquincho, Martín pescador, Huemul (SAG, 2006)	Quirquincho, Martín pescador, Huemul (SAG, 2006)

Zone 1: Head of the basin Coyhaique Alto – Las Bandurrias

Zone 2: Intermedium zone Las Bandurrias – Tejas Verdes

Zone 3: Urban Coyhaique Las Bandurrias – Confluence Simpson river

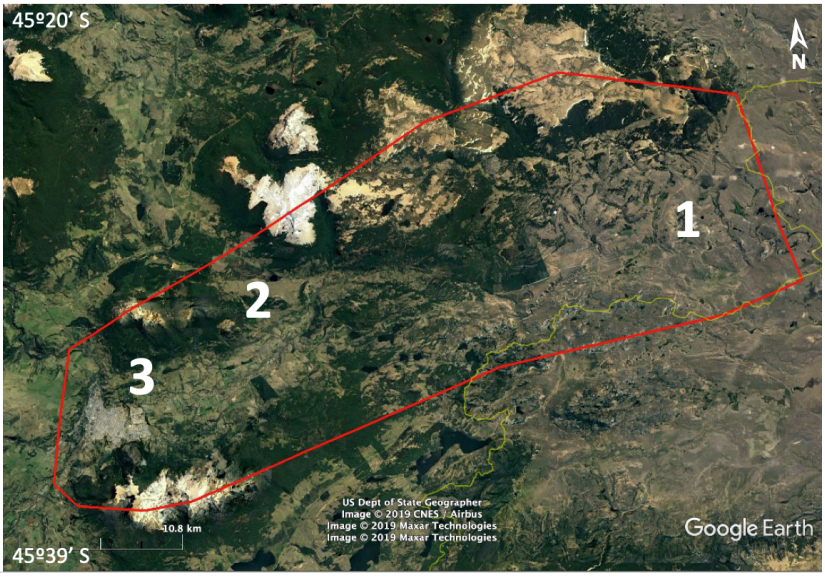

Figure 4. Zonification of the Coyhaique river basin.

3.2.2 Analysis of information

Zone 1: Coyhaique Alto – Puente Las Bandurrias

The upper part of the Coyhaique river basin differs from the rest of the basin because of its steppe landscape and unique land use. This area had an active development of extensive livestock in the valleys and summits. The size of the properties is more than 200 ha, and few owners divide this territory. The population density is very low and is concentrated in the border crossing with Argentina. In this area, there is also a military base, which restricts the access and exploitation of natural resources.

Among the current uses of zone 1 are: extensive livestock (low parts) and summers (at the summits), fly fishing, and tourism (bird watching, hiking, and gaucho cultural experiences). The forestry activity is minor; there are extensive private plantations of Pines sp. (in abandonment). The native forest is located in the summits of the basin and is used for firewood.

There is also a Nacional Monument Park (Natural Monument Dos Lagunas) and a Military Base (Las Bandurrias).

Table 2. Ecosystem Services present on the zone 1:

1	Provision	- Water quantity -Biomass (Lenga wood, pine) - Forage animals (lambs and cows)
2	Support	-Biodiversity (terrestrial and aquatic) -Water quality -Habitat of endangered species: Huemul (E), Carpenter bird (VU) -Endangered landscape: Mediterranean steppe.
3	Regulation	-Water cycle
4	Cultural	-Tourism of special interests (fly-fishing, sighting of condors, walks) -Potential archaeological sites

Zone 2: Puente Las Bandurrias –Tejas Verdes

The intermediate zone is characterized by the decreasing size of the properties, relative proximity, and access from the city of Coyhaique. This zone has a recent real estate development without much regulation since it is not within the regulatory plan of the city of Coyhaique, and there is some problem with water availability in dry years. This area stands out for the

coexistence of 0.5 ha land with some larger ranches that still produce livestock, pasture management, and crops. Among the most representative uses of zone 2 are livestock ranching (in the plains and summits of the hills during the summer); recreational fishing (tourism for local people), agricultural development (cereal crops and food for local consumption); and extraction of gravel in the riverbank. The forests are in the high mountains and do not have public access. There are firewood exploitation and forest plantations of Pines sp. (in abandonment). The current condition of the forest or current management plans is unknown.

Table 3. Ecosystem Services present on the zone 2:

1	Provision	- Water quantity - Biomass (Lenga wood and pine) - Forage animals (lambs and cows) - Food (agricultural production, regional consumption)
2	Support	-Biodiversity (terrestrial and aquatic) -Water quality -Habitat of endangered species: Huemul (E),
3	Regulation	-Water cycle -Erosion control
4	Cultural	-Tourism (fishing camping and walks) - Scenic value

Zone 3: Tejas Verdes – Confluence with Simpson River

This area corresponds to the urban area of Coyhaique, it is regulated by Urban planning and it has a population of over 60,000 people (Censo, 2017), which mostly inhabit the southern bank of the Coyhaique River. On the north bank, there are properties on average higher than 0.5 ha, which develop agricultural products, livestock, and firewood for home or local consumption.

The Coyhaique River is isolated from the city, with very few points of access. Although there have been attempts at cleaning and integration through the creation of urban parks, these have not been successful. The Coyhaique River has a high disturbance, due to garbage (solid and liquid), invasion of exotic species (willows, pines sp., and dogs), urban settlements without regulation, which together make it a geographical feature of little pride for the city.

In this zone, there is pressure for water rights. Aguas Patagonia, an urban water private distributor, operates in this area. The city's water supply comes from three streams on the southern slope of the basin (Estero Seguel, La Cascada, and El Carbón). According to information from the Superintendent of Sanitary Services, in 2006, Aguas Patagonia extracted 360 l/s of these three estuaries and 300 l/s of the Coyhaique river to supply water to the city (DGA, 2004). There is no information available on the state of the forest in the estuaries that supply the city with water.

The native forests are found mainly in the high summit area of the north bank of the river, in the Coyhaique Nature Reserve. The south bank is replanted with extensive areas of Pinus sp, which are in imminent danger of forest fires due to their planting density, slope, and proximity to the city. There is no updated information on the condition of the native and exotic vegetation.

Table 4. Ecosystem Services present on the zone 3:

1	Provision	- Water quantity -Food (agricultural production, household consumption) -Biomass (Lenga wood and pine) -Forage animals (lambs and cows)
2	Support	-Water quality -Habitat of species
3	Regulation	-Water cycle -Erosion control
4	Cultural	-Tourism (fishing camping and walks)

The three zones present different potentialities of use and associated risks for the conservation of ES (Table 5). Superficially, there is no general degradation in the condition of the basin, but there is no empirical data to confirm this. Coyhaique is one of the most air-polluted cities in Chile during the winter due to the burning of moist wood for heating. Recent studies have been conducted to evaluate the problem, but these do not consider the long-term effects of the population's health or concrete actions to reduce the use of wet firewood.

Table 5. Potential for development and their potential risk in the three zones

	Potential for Development	Potential Risk
Zone 1: Coyhaique Alto – Puente Las Bandurrias	- High potential of the conservation on intact watersheds (a few owners). - Private sector interested in sustainable tourism and in maintaining cultural activities. - Low population pressure. - Potential to develop eolic energy.	- Nobody leading the path. - MININCO (private forestry Co.), owns 1.200 Ha of Ponderosa and Contorta pines and do not have a management plan. - Inexistence of a preventive forest-fire program, invasive species control (animals, vegetation, algae, and pests). - Valley is crossed by an international route that lacks environmental information about these ecosystems and vulnerability. - Army base does not provide information about their practices.
Zone 2: Puente Las Bandurrias – Tejas Verdes	- Agro-tourism or tourism, mostly for local population. -Small scale agriculture and cattle livestock production.	- All water rights are sold -Intense land use (forestry/agriculture/livestock) without regulations - Lack of regulation of Gravel extractions - Lack of control of the use of agrochemicals - Rapid urbanization without planning (parceling) - Invasive species like willow, lupines, pines, dogs. - Erosion
Zone 3: Tejas Verdes – Confluence with Simpson river	- Some agricultural uses (household consumption) - Intense land use - Restoration of the river banks and creation of urban parks	- Air pollution - Water availability and quality - Dangerous access to natural areas - Pressure for urbanization -Unaffordable prices of everything starting with housing, food, transportation, energy.

3.2.3 Recommendations for actions

Thus, there is a need to quantitatively analyze natural resource practices and their effect on the ecosystem services provided

3.3. Interviews and Surveys/Social context and Diagnosis

The term Ecosystem Services was used after its formal definition by the Millennium Ecosystem Assessment (MEA) in 2005. However, its use and incorporation into rural vocabulary is rare, because it requires a definition of “service” and “ecosystem,” which demonstrates a separation between who is the user and the beneficiary of the services that a specific ecosystem function provides (MMAmb, 2016).

To define the perception and contemporary use of the term “ecosystem service” in the Coyhaique river basin, this study identified the individual(s) that directly benefit from these services, and the individual(s) that based their economy on the use of natural resources. For this purpose, interviews and surveys were conducted on both residents and decision-makers (government and private) that influence the use and management of natural resources in the basin. The surveys identified key ES of forests and their challenges for its conservation (wood and water), their direct use, management, and governance.

3.3.1 Hypothesis, objectives and Methods

Objective: Describe the stakeholder perspective related to the use and governance of natural resources (forest, water and economy).

Hypothesis: Rural people in Patagonia who depend on their use of natural resources would not use sustainable land use practices during the cold season (fall-winter-spring) in order to subsist.

Methods: A total of 41 semi-structured interviews and 10 surveys were conducted. The interviews had an average duration of 60 minutes (appendix III). The surveys were responded to by individuals who are representative sample of the diversity of the population of the basin. They were selected according to their economic category, ethnicity, sex, land tenure and location in the basin, to obtain a general and objective image of the different uses and socioeconomic characteristics of the Coyhaique river basin (figure 5). The choice of subjects prioritized a diversity of perspectives on the issues in question (Chambers, 1997; Schoonmaker, 2008). The survey consisted of both open and closed questions, divided into 11 categories: 1) Demographic, 2) Poverty, 3) Food Health and Safety, 4) Land Tenure, 5) Income, 6) Soil Fertility, 7) Water Management, 8) Harvest, 9) Marketing and sales, 10) Organization and 11) Perception of changes in the landscape and Ecosystem Services (appendix IV). The results of the interviews and surveys are integrated into the discussion and used to recommend future strategies.

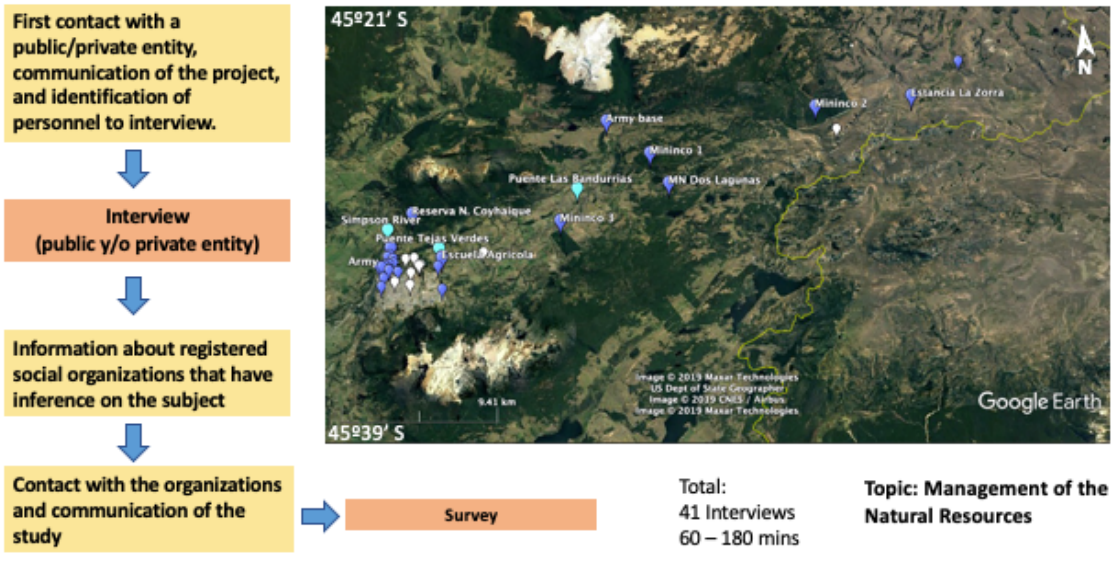

Figure 5. Diagram of identification of the interviewees and survey respondents. Every selected person has inference in the natural resources of the Coyhaique river basin. On the map, the white dots represent the people that was surveyed, and the purple dots the interviewers.

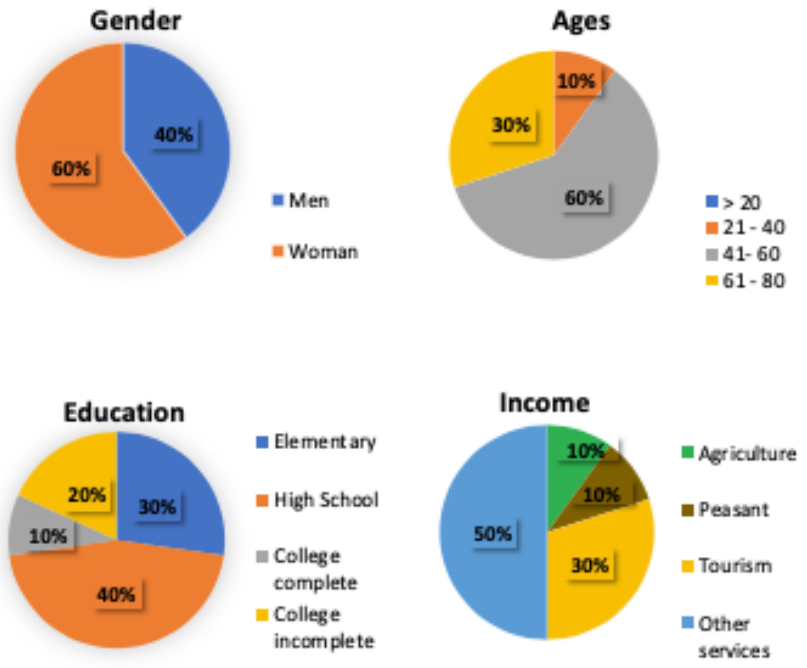

Figure 6. Demographic descriptors of the surveys, a) Gender; b) Educational level; c) Age; d) Main activity, "Other services" refers to a small market, domestic employee, guard, teacher, sales. Main activity is considered to be the constant source of income or from which it is possible to subsist for a whole calendar year. The activity that supplements income vary depending on the opportunity; for example, a domestic employee during the summer also sells vegetables, who buy firewood at a reasonable price in the summer, sells firewood in the winter, who has a truck also offers transportation services.

3.3.2 Results

Ecosystem Services (ES)

The main result is that people had no problem with the concept of Ecosystem Service. Water supply, erosion control, and air quality (Figure 7) were the most mentioned as ES. Air quality as an ES, is debatable, because the survey was applied during the winter. The city of

Coyhaique is the most air-polluted city in the country and South America due to the burning of wet fired wood, which produces the highest index of PM 2.5 and PM 10 (Molina, et al., 2017).

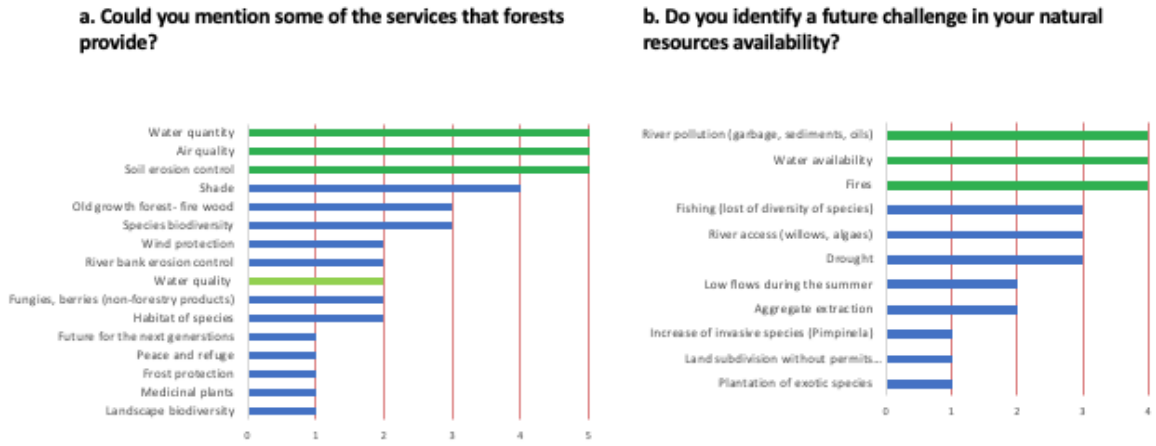

Figure 7. a) Could you mention some of the services that forests provide?, b) Do you identify a future challenge in your natural resources availability? Both questions were open, and the respondents had no limit on the number of "Services" or "the challenges" they identified. The graph represents the number of people who identified that particular "Services" or "challenge."

Water availability has become an increasing concern due to drought seasons, where some areas in Coyhaique city had been affected without water supply. Many of the respondents have experienced the drought directly by having their streams dried up or having a significantly decreased in the flow during the past years. Water quality, as an ES of the forest, did not show greater relevance for respondents.

The forest

Firewood is used for both heating and cooking. Most of the firewood consumed in the Coyhaique and Aysén region, comes from native forests, either within the Coyhaique river basin or in nearby basins. The firewood used corresponds to Nothofagus species, among them Lenga

(*N. pumilio*), Coigue (*N. dombeyi*), and Ñirre (*N. antactica*). Ñirre is the most valued for its caloric power, with the highest price in the market. Recently, the use of Pine from forest plantations has been incorporated in the market.

The firewood market is informal, and although there is a concern about its regulation, a few efforts had yielded results (CONAMA, 2009). Of those surveyed, 90% responded that they did not know if their firewood comes from a forest with a management plan or does not care that they did not have it (10%), because the price was more relevant. Respondents buy firewood during the summer on the roadside, and they transported it to their property (to reduce costs). The price of certified dry firewood is approximately 28 USD/m^3, while on the roadside, it is 18 USD/m^3, and on average, a family consumes 25m^3/year. The price increase, is due to the cost of storage, drying, transportation, and taxes (MMAmb, 2016b, Ministerio de Energia, 2017). The sectors from which respondents bought their firewood were Lake Castor, Lake Pollux, Villa Ortega, Cerro Mano Negra, and El Verdín.

The water

The Coyhaique river basin has excellent access to drinking water, either rural drinking water or through the company, Aguas Patagonia. It is for this reason that 60% of respondents rely on Aguas Patagonia to irrigate their crops, provide water to their animals, or for household consumption. The irrigation used varied among peasants; these range from sophisticated systems like drip irrigation (10%), use of grooves, or the use of a hose. Only 10% acknowledged not using any irrigation for their potato and garlic crops, but these are intended for family consumption (not for sale).

There is a concern for the water supply and drought in the region (figure 8), however in the case of the respondents, none of them made any improvement or protection of their water sources, and only 30% said they had registered rights to use surface water. In Chile, water rights are private, and although there are still rights available in the Coyhaique river basin, the paperwork process is complex and requires professional advice. The government can subsidize these costs, but the farmer needs to be the owner or lessee of the land and cannot have debts with the government. It is for these three reasons that 60% of respondents cannot apply to obtain water rights.

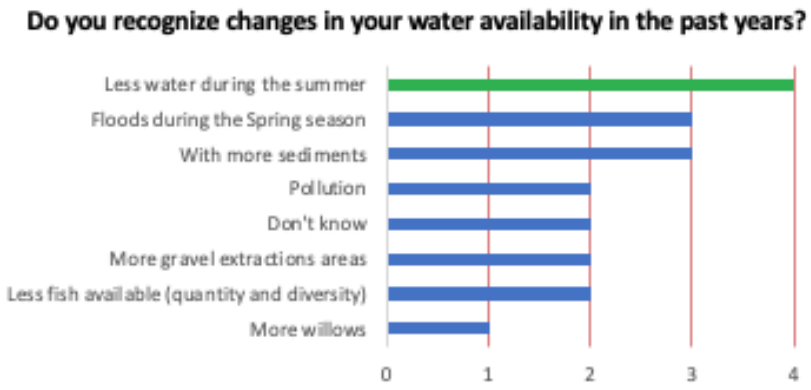

Figure 8. Do you recognize changes in your water availability in the past years? 40% of respondents acknowledged the existence of a lower amount of available water during the summer.

Governance, Government incentives and effectiveness

Due to the difficult access, the remoteness from the central government, and the history of colonization, the government is a crucial driver of regional development. The Coyhaique river basin is home to the regional capital, concentrating all regional public services. That is why, in theory, smallholders and entrepreneurs could have greater access to development opportunities than those in more isolated corners of the region. For instance, the question "Do you participate

in any agricultural organization?" was aimed to understand the degree of involvement and access of respondents to government programs. All respondents had participated or were participating in a government program. The programs most popular were: the "Reforestation" programs from the National Forestry Corporation (CONAF), "Cleaning of lands, fertilizers and fences" from the Agricultural Development Institute (INDAP), and training, financing, and marketing programs from the Technical Cooperation Service (SERCOTEC).

When asked if these financial supports and/or training have had a positive effect on their businesses, the response was confusing. Everyone thanked them for the help; however, they did not necessarily fit their needs but were accepted for being free, grant them knowledge about other programs, and make them known within the organizations or consultants of these organizations. For the question "Could you mention any improvement made in your ranch after participating in a workshop?" (Figure 9) The responses varied; in the case of physical improvements of the land, such as pine plantations and infrastructure construction, they saw a direct relationship of improvement in their lands. However, this did not mean an improvement in their quality of life — for example, the greenhouses from Israel. Even though the greenhouse helps the peasant to extend the summer season, this greenhouse is designed for the climatic conditions of Israel, not Patagonia, and size and height make it a danger with the winds and often had to incur on expensive repairs. Another example is the Pine plantations, which are delivered, planted, and designed by CONAF. They are usually planted at a maximum density to ensure the survival, but also because the CONAF consultant must meet planting quotas. Once planted, they are the owners' responsibility. Many owners are left with shady, dense lands and with imminent risks of fires in their lands since they do not have the capacity to manage these plantations.

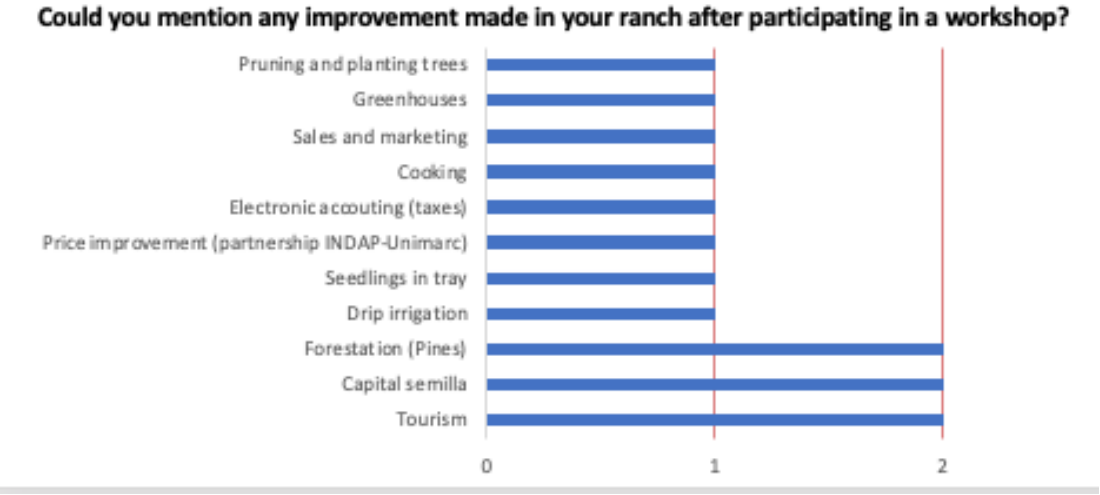

Figure 9. Could you mention any improvement made in your ranch after participating in a workshop?

3.3.3 Recommendations for actions

Thus, there is need to analyze the historic policies and the context to determine the current use of natural resources.

4. CONCLUSION AND RECOMMENDATIONS FOR ACTIONS

The history of colonization and land management of Aysén has been decisive in the current condition and potential development for the Coyhaique river basin. Unfortunately, there is not enough information to characterize the current condition of the basin at the local level; thus, it is necessary concentrate the efforts on the quantification of the terrestrial and aquatic ecosystems. Specifically, this study recommends developing maps and census of terrestrial and aquatic vegetation, inventories of exotic species and their current and potential effects, increase the number of meteorological stations and streamflow gauges for continuous monitoring. With this information, it will be possible to propose sustainable development plans for the basin and

focus economic resources and government programs on concrete actions aimed at maintaining and improving the quality of life of its inhabitants.

The regions in the basin that presented a lower degree of use, substitution, and intervention of the native forest, conclusively show a greater diversity of ecosystem services and potential for diversification of uses. The upper part of the Coyhaique river basin (zone 1), due to its difficult access and low population density, concentrates the largest area of native ecosystems and native forests in the high mountain areas. The existence of old-growth forest is potential and based on ethnographic information and the 1996 Native Forest Census. Their current existence and condition must be quantified in order to understand their ecosystem function within the basin.

Zone 1 has the lowest level of exploitation compared to the other two zones, as a result of few owners, and small or concentrated interventions on the land. This shows the essential role and impact of landowners on the land use and conservation. When there are many owners (zone 2 and 3), each one tends to maximize the use of its territory. According to the Land Capability Class Index IV, the soils of the basin need rotations and specialized care for their maintenance in order to avoid further erosion. The decrease and fractionation of the properties size make them more susceptible to these rotations not being carried out and continuing the process of degradation. It is for this reason that although some farmers want to make sustainable management of their resources, they are limited by the condition and size of their land, which, together with economic pressures during the winter season, make them choose unsustainable decisions in order to subsist.

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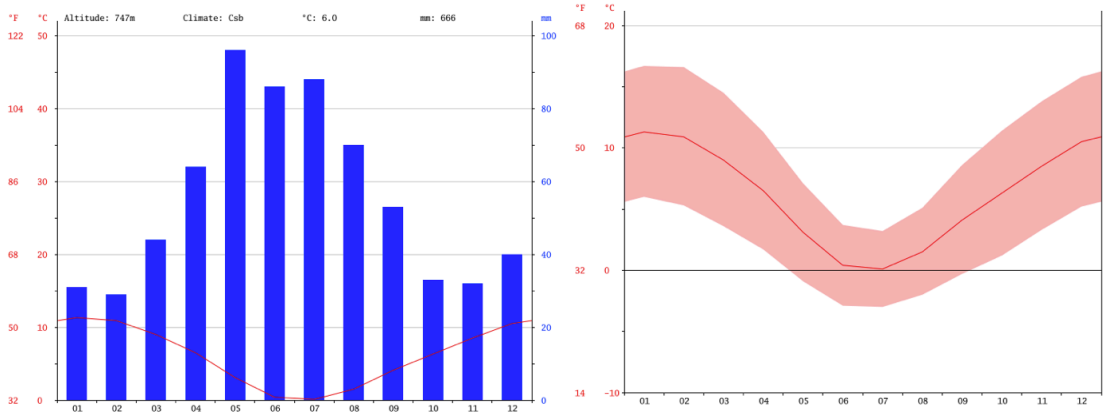
APPENDIX I. Climate Graphs

1. Coyhaique Alto Weather Station

1.1 Precipitation and Temperatures.



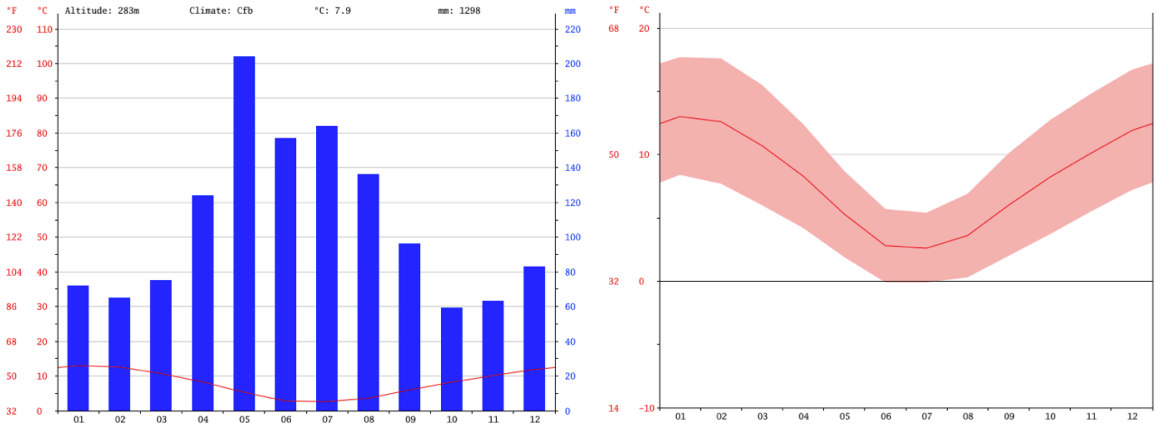
The lower precipitation is in February, with an average of 29 mm. Meanwhile, May is the month that has the highest average precipitation with 96 mm. The average temperature is 11.3°C during January (summer) and 0.1 °C on July (winter). According to Köppen and Geiger, this climate is classified as Csb. The average annual temperature in Coyhaique Alto is 6.0 °C. Precipitation here averages 666 mm (https://en.climate-data.org/south-america/chile/region-aysen-del-general-carlos-ibanez-del-campo/coyhaique-alto-148735/).

1.2 Coyhaique Alto Weather by Month/Averages (https://en.climate-data.org/south-america/chile/region-aysen-del-general-carlos-ibanez-del-campo/coyhaique-alto-148735/)

	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre
Temperatura media (°C)	11.3	10.9	9	6.5	3.1	0.4	0.1	1.5	4.1	6.3	8.5	10.5
Temperatura min. (°C)	6	5.3	3.6	1.7	-0.9	-2.9	-3	-2	-0.3	1.2	3.3	5.2
Temperatura máx. (°C)	16.7	16.6	14.5	11.3	7.1	3.7	3.2	5.1	8.6	11.4	13.8	15.8
Temperatura media (°F)	52.3	51.6	48.2	43.7	37.6	32.7	32.2	34.7	39.4	43.3	47.3	50.9
Temperatura min. (°F)	42.8	41.5	38.5	35.1	30.4	26.8	26.6	28.4	31.5	34.2	37.9	41.4
Temperatura máx. (°F)	62.1	61.9	58.1	52.3	44.8	38.7	37.8	41.2	47.5	52.5	56.8	60.4
Precipitación (mm)	31	29	44	64	96	86	88	70	53	33	32	40

2. Coyhaique City, Teniente Vidal Weather Station

2.1 Precipitation and Temperatures.

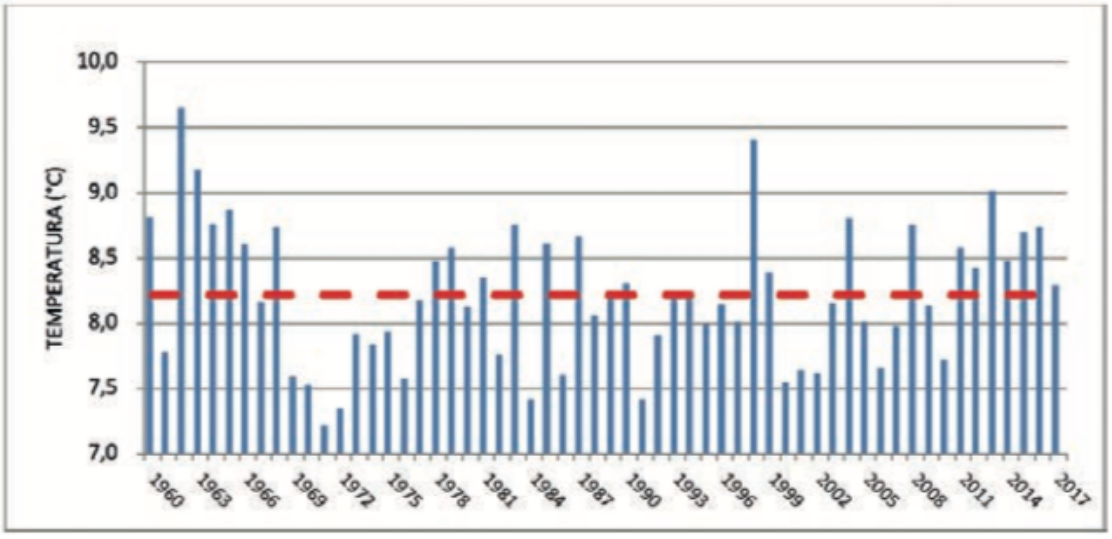


Coyhaique has a significant rainfall throughout the year. The driest month still has a lot of rainfall. Climate is classified as Cfb by the Köppen-Geiger system. The average annual temperature in Coyhaique is 7.9 °C. The average annual rainfall is 1298 mm. (https://en.climate-data.org/south-america/chile/region-aysen-del-general-carlos-ibanez-del-campo/coyhaique-2055/).

2.2 Coyhaique Alto Weather by Month/Averages (https://en.climate-data.org/south-america/chile/region-aysen-del-general-carlos-ibanez-del-campo/coyhaique-2055/)

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	13	12.6	10.7	8.3	5.3	2.8	2.6	3.6	6	8.2	10.1	11.9
Min. Temperature (°C)	8.4	7.7	6	4.2	1.9	-0.1	-0.1	0.3	2	3.7	5.5	7.2
Max. Temperature (°C)	17.7	17.6	15.5	12.4	8.7	5.7	5.4	6.9	10.1	12.7	14.8	16.7
Avg. Temperature (°F)	55.4	54.7	51.3	46.9	41.5	37.0	36.7	38.5	42.8	46.8	50.2	53.4
Min. Temperature (°F)	47.1	45.9	42.8	39.6	35.4	31.8	31.8	32.5	35.6	38.7	41.9	45.0
Max. Temperature (°F)	63.9	63.7	59.9	54.3	47.7	42.3	41.7	44.4	50.2	54.9	58.6	62.1
Precipitation / Rainfall (mm)	72	65	75	124	204	157	164	136	96	59	63	83

2.3 Coyhaique (Teniente Vidal weather station). Historic Temperatures records 1960-2017 (Hepp et al, 2018).



Annual average historic temperature for Coyhaique City. The discontinue line indicate the normal annual temperature (Hepp et al, 2018).

APPENDIX II. List of plant species presents on the Cold steppe of Aysén (SAG- Protección de Recursos Naturales de Aysén).

Common Name	***Scientific name***
Cadillo	Acaena leptacantha Phil.
Pimpinela	Acaena magellanica
Cadilla	Acaena ovalifolia R. et P.
Cadillo	Acaena pinnatifida R. et P.
Pimpinela	Acaena sp.
Cepa de caballo	Acaena splendens H. et A.
Milenrama	Achillea millefolium
Paramela	Adesmia boronoides Hook f.
	Adesmia sp.
	Agropyron sp
Chépica	Agrostis castellana Boiss et Reuter
Chépica	Agrostis magellanica Lamark.
Chépica	Agrostis sp.
Chépica	Agrostis tenuis
	Alopecurus aequalis Sobolewski
	Alopecurus geniculatus var.patagonicus Parodi
	Alopecurus magellanica
	Alopecurus sp
	Anagallis arvensis
	Anagallis sp.
Neneo macho	Anarthrophyllum desideratum
Anemona, centella	Anemone multifida Poir.
	Arenaria sp
Siempre viva	Armeria chilensis (sin. Armeria maritima)
Avena, avenilla	Avena sp
	Ayra caryophylea
Aromo	Azara lanceolata Hook. f.
	Azara sp
	Azorella caespitosa
Vautro chico	Baccharis concava, B. eleaoides Remy
	Baccharis magellanica
	Baccharis sp.
Calafate	Berberis buxifolia
Michay	Berberis darwinii Hook
Calafate	Berberis emprtrifolia Lam.
Michay	Berberis linearifolia Phil.
Michay	Berberis negeriana Tischler.
Michay del bosque	Berberis serratodentata
Pasto serrucho, pinque	Blechnum penna-marina (Poiret) Kuhn.
Bromo	Bromus molle

Bromo	Bromus rigidus
Bromo	Bromus saetifolius
Bromo	Bromus secalinus L.
Bromo	Bromus sp
Bromo	Bromus stamineus E. Desv. (ex B. valdivianus)
Arguenita, topa topa.	Calceolaria biflora
Arguenita, topa topa	Calceolaria sp
Arguenita, topa topa	Calceolaria tenella Poepp.
Placa	Caltha sp
Cerastio	Capsella bursa-pastoris
Malaria, brava, cardaria	Cardaria draba
	Carex gayana
	Carex amaetorrhincha Desvaux.
Cortadera	Carex andersonii Bott in Hook
	Carex banksii Boott.
Cortadera	Carex darwinii Boott.
	Carex goodenoughii
	Carex macloviana d'Urville.
	Carex sp
Cerastio	Cerastium fontanum Baumg.
Cerastio	Cerastium sp
Cardo negro	Cirsum vulgare (Savi) Airy - Shaw
Yaqui	Colletia spinosissima
Colliguay	Colliguaya integerrima
Cortadera	Cortaderia sp.
	Ctenitis spectabilis (Kauf) Kunkel
	Cyptopteris sp.
Mata verde	Chiliotrichium diffusum
	Chloraea sp.
	Deschampsia antarctica Desvaux.
	Deschampsia flexuosa (L.) Trinius.
	Deschampsia laxa Philippi
	Deschampsia sp
	Deschampsia venustula Philippi
	Deyeuxia eritrostachya Desvaux
	Deyeuxia sp.
	Dichondra sp.
Chacay	Discaria serratifolia Vent (B. et H.)
Chacay	Discaria sp
	Draba magellanica
	Draba sp.
	Draba verna
Yodo de campo	Echium vulgare
	Elymus antarcticus Hooker

	Elymus patagonicus Spegazzini
	Elymus sp
Notro, ciruelillo	Embothrium coccineum
Brecillo, murtilla de Magallanes	Empetrum rubrum Vahl ex Willd.
	Epilobium chilense (Epilobium magellanicum Phil et Hausskn.)
	Epilobium magellanicum Phil. et Hausskn.
Alfilerillo, relojito	Erodium cicutarium
	Erygeron myosotis Pers
	Erygeron sp.
	Escallonia rubra
	Escallonia sp.
Meki, möki, liun, mata negra, chapel	Escallonia virgata (R. et P.) Pers
Coirón	Festuca magellanica
Coirón	Festuca pallescens
Coirón chico	Festuca pyrogea Sperg. (sin. F. ovina)
Coirón chico	Festuca sp
Frutilla	Fragaria chiloensis
	Galium aparine L.
	Galium sp
	Gamochaeta sp.
	Gamochaeta stachidifolia (L) Cabrera.
Murtillo	Gaultheria caespitosa Poepp et Eudl.
Chaura, murtillo	Gaultheria phillearyfolia (Pers.) Steumer
Chaura, murtillo	Gaultheria sp
Core core	Geranium berterianum Colla.
Core core	Geranium core-core
Core core	Geranium molle L..
Core core	Geranium sessiflorum Cav.
	Geum chilense (G. parviflorum)
Hierba del clavo	Geum quillon
Hierba del clavo	Geum sp.
	Glandularia sp.
Pasto maná	Glyceria fluitans (L.) R. Br.
Pasto miel	Holcus lanatus
Cebadilla,cola de ratón,	Hordeum comosum Persl.
Cebadilla,cola de ratón, ratonera	Hordeum chilense.
Cebadilla,cola de ratón, ratonera	Hordeun sp
Malva de monte	Hydrocotyle chamaemorus Cham. et Schlecht.
Hierba del chancho	Hypochoeris radicata L.
Junco	Juncus balticus Willd.
Junco	Juncus chilensis Gay.
Junco	Juncus involucratus Steud aupud Buchenau

Junco	Juncus lesueurii Bolander
Junco	Juncus procerus E. Meyer
Junco	Juncus sp.
	Lagenophora hairotii Franchet.
	Lapsana communis L.
Arvejilla	Lathyrus hookeri G.
Arvejilla	Lathyrus sp.
Mata negra, mata retorcida	Lepidophyllum cupressiforme
	Leucheria sp.
	Linaria vulgaris
Ballica italiana	Lolium multiflorum
Ballica inglesa	Lolium perenne
Ballica	Lolium sp
Chocho	Lupinus albus
Chocho	Lupinus arboreus
Chocho	Lupinus sp
	Luzula chilensis Nees et Meyen aupud Kunth.
	Luzula sp
	Macrachaenium gracile Hook. f.
Melosa	Madia sativa Mol.
Maitén	Maytenus chubutense
Racoma, maitencillo	Maytenus disticha (Hook. f.) Urban
Maitén	Maytenus magellanica
Alfalfa	Medicago sativa
	Medicago sp
Trebol dulce	Melilotus sp
Menta	Mentha piperita
Menta	Mentha sp
Neneo	Mulinum spinosum (Cav.) Pers.
Clavel del campo	Mutisia decurrens Cav.
Clavel del campo	Mutisia sp
Clavel del campo	Mutisia spinosa R. et P. var. espinosa
Orocoipo	Myoschilos australis
	Myriophyllum elatinoides Gand.
Escarapela	Nassauvia dentata Griseb.
Ñirre	Nothofagus antarctica (G. Foster) Oerst.
Coigüe	Nothofagus dombeyi (Mirbel) Oerst.
Coigue de Chiloe	Nothofagus nitida
	Notholaena mollis
Cactus	Opuntia australis (Sin. Austrocactus patagonicus)
Perejíl de monte, asta de cabra	Osmorhiza chilensis Hook et Arm.
Botellita	Ourisia ruelloides (L.f.) Gaertn.
Pillo pillo	Ovidia andina
	Oxalis

	Perezia linearis Less.
Estrella de los Andes	Perezia peduncularidifolia Less
Chaura	Pernettia mucronata (L. f.) Gaud. ex Spreng.
Chaura	Pernettya sp
	Phacelia sp
Pasto timoteo	Phleum pratense Linné.
Fleo, pasto timoteo	Phleum sp
Pino cotorta	Pinus contorta
Pino ponderosa	Pinus ponderosa
Llanten	Plantago australis spp cumingia (Fish. et Mey.) Rahn.
Llantén, siete venas	Plantago lanceolata
LLantén, siete venas	Plantago major
LLantén, siete venas	Plantago media
LLantén, siete venas	Plantago sp
Cortadera, poa de mallín	Poa andina Trinius.
Piojillo	Poa anua
Poa	Poa borchersii Philippi.
Poa	Poa pogonantha (Franchet) Parodi
Nombre común	Nombre científico
Poa, pasto mallín	Poa pratensis Linné.
Poa clorandica	Poa rigidifolia Steudel. (Poa fueguina)
Poa	Poa sp
Poa	Poa stenantha Trinius
Poa	Poa superbiens (Steud).
Cola de ratón	Polypogon australis Brong.
	Polypogon semiverticillatus (Forsk) Hylander
	Polypogon sp.
Alamo plateado	Populus alba
Alamo híbrido	Populus euroamericana
Alamo, chopo	Populus nigra
Hierba de la plata	Potentilla anserina
Hierba mora	Prunela vulgaris
Pino oregón	Pseuditsuga menziesii
Quinchamalí	Quinchamalium chilensis
	Ranunculus repens
	Ranunuculus sp.
	Rhytidosperma glabra
	Rhytidosperma sp
	Ribes cuculatum
Parrilla, zarzaparrilla	Ribes magellanicum Poir
	Ribes sp
Mosqueta	Rosa moschata
Miñe miñe	Rubus geoides Sm.
Vinagrillo	Rumex acetosella

Romaza	Rumex crispus
Sauce llorón	Salix babilonica
Sauce alemán	Salix capra
Mimbre	Salix viminalis
	Scirpus californicus (crec. A. Mey.)
	Scyrpus sp.
Laura	Schinus marchandii
Clavelillo	Schizopetalon sp.
Trompetilla	Senecio acanthifolius Hombr. et Jacq.
	Senecio argyreus Phil.
	Senecio chionophilus Phil (ex S. hollermayeri)
	Senecio filaginoides decr.crec.
Yuyo moro	Senecio naei
Yuyo moro	Senecio naei decr. crec.
	Senecio otites Kunze ex decr. crec.
	Senecio patagonicus
	Senecio smithii decr.crec.
	Senecio subdiscoideus
Ñuño	Sisyrinchium sp.
	Solidago chilensis
	Spergula sp
	Spergula villosa
Quilloi quilloi	Stellaria cuspidata Willd
Quilloi quilloi	Stellaria media
Quilloi quilloi	Stellaria sp.
Paja de campo	Stipa brevipes Desvaux.
Coirón amargo	Stipa laevissima
	Stipa longipes
	Stipa plumosa
Coirón amargo	Stipa speciosa
	Stipa tipo huecú
	Triflium filiformis (sin. T. dubium)
Trebol rosado	Trifolium pratense
Trebol blanco	Trifolium repens
	Trisetum caudulatum Trinius
	Trisetum cernuum Trin.
	Trisetum flavescens
	Trisetum sp
	Trisetum spicatum
	Uncinia tenuis Poepp. ex Kunth.
Ortiga	Urtica urens
Valeriana	Valeriana fonkii Phil.
Guahuilque	Valeriana lepathifolia Vahl
Papilla, ñanco lahuén	Valeriana papilla decr. crec.(sin Valeriana carnosa)

Valeriana	Valeriana philippiana Briq.
Valeriana	Valeriana sp.
Hierba del paño	Verbascum sp
	Verónica sp
Arvejilla	Vicia sp.
Violeta amarilla	Viola reichei Skottsb.
	Viola sp
	Vulpia dertonensis
	Vulpia sp

APPENDIX IV. Survey

I Demographic information:

1. Interviewee name:
2. Farm name and location
3. GPS coordinates (latitude, longitude, altitude)
4. Sex
5. What is your role in the household?
6. How long have you lived here?
7. What is your country of origin?
9. How many family members live on your ranch? What are their sex, age, years of school completed, occupation, student status?

Member	Gender	Age	Scholarity	Name of the school	Occupation

II Poverty information:

10. What is your electric source?
11. What fuel or energy source does the household usually cook with?
12. Which kind of wood do you use and where does it come from?
13. What energy source does the household use to heat the house?
14 Does the household have a bathroom inside the house?
15. Does the household have a radio, cellphone signal?
16. Does the household have a car/gravel road to access the property?
17. In their main line of work, how many household members work as wage or salary employees for a private firm or the government?
18. Do you have a storage, toolshed, or animal shed?

III Health and Food security Information:

19. Last time visiting the doctor? (Health provider visited, household member)
20. Chronic diseases? (household member, health problem)
21. Description of diet

Breakfast	Lunch	Dinner	Snacks

22. Where does the food come from? (distance and source)
23. Amount of money spent on food approx. (US $/month)
24. In the past 12 months, were there months in which you did not have enough food to meet your family's needs?
25. If yes, which were the months?

IV Farm Tenure

26. How did you acquire your land?
    a) Inheritance
    b) Government
    c) Marriage
    d) Leasing
    e) Loan
    f) Purchase
27. Do you have a land title?
28. How many hectares of:
    a) farm area?
    b) pasture area?
    c) Forest area (which types)?
    d) Uncultivated area?
    e) Conservation area?
    f) Total area?
29. If you have a conservation area, why do you have it?
30. What natural resources are in your property?
    a) Natural spring
    b) Forest, prairie, steppe (type)?
    c) River/creek/stream
    d) Lake/lagoon
    e) Other
31. Is your farm within a reserve? If yes, which?

V Income:

32. What crop/livestock/forest products do you grow/produce?
33. What is your income this year on average per product?
34. What is your annual production per product?
    a) Has this increased, decreased, or stayed the same in recent years?
    b) When was production the lowest and what was the cause of the decreased production?
35. How much area is devoted to each product?
36. What is the sales price per product the past year?

37. Which crops, livestock ,or forest products would you like to include in your farm that you don't have now?
38. What non-agricultural activities provide you income?
39. What is the annual income from these external activities?
40. What about other members of the family?
41. What are the sources of income per season for the household by member

Summer	Fall	Winter	Spring

VI Soil fertility:

42. Do you conduct soil analysis on your farm? And how long has it been since your last soil analysis?
43. Do you fertilize? What material/use/quantity/frequency?
44. Where does the fertilizer comes from?
45. Do you have soil erosion problems? (when they started, cause related)
46. Do you irrigate your crops? What type of irrigation do you use and how often?

VII Water management:

47. Where does the water come from? (well, creek, city water, other) and what is the use that you give it? Do you protect the water source from animals through fencing or any other action?
48. How much water do you receive annually on your farm? Would you consider to obtain a water right/permit? Has that increased, decreased, or stayed the same since you started farming? Has any of the water sources run dry?
49. Do you manage runoff? Do you know the name of the river that water runs off?
50. Do you recognize changes in your water availability compared with last year?

VIII Harvest

51. What are the products that you produce from your ranch?
52. How do you store your products? (where and how)
53. Do you dry your products before selling?
54. What drying technologies do you use or know that you can implement?
55. How long do you store your products before selling it?
56. Do you collect non-forestry products? (wild mushrooms, calafate, wild strawberries, rosehip, fiber)

IX Marketing and sales

57. Where do you sell your products?
58. Do you deliver your products? And how often do you sell them?

59. Do you sell raw material, or do you increase the value producing something else? (ex. Raw wool to yarn; whole animal – smoke meat; stand forest – timber)
60. Do you keep a record of your sales?
61. Do you have a management plan for your ranch? Do you follow it?
62. Do you identify challenges to increase your productivity?
63. Do you participate in rural tourism activities?
64. If yes, which service or product do you provide? How often? How do you market your services? Are you satisfied with this activity?

X Organization:

65. Do you participate in any agricultural organization? (livestock producer, forest programs, INDAP, PRODESAL)
66. Do you participate in their workshops? What was the motivation to participate?
67. Could you describe any improvement made in your ranch after that workshop?

XI Changes on the landscape and natural resources

68. Could you mention big changes in your landscape that impacted your ranch and how these changes impacted your livelihood? (ex. Construction of gravel road, electricity line, cellphone signal)
69. Do you recognize any change in your Ranch that could be related with the use? Landslides? Loss of soils? Gullies? Soil compaction?
70. Could you mention some of the services that forests provide?
71. Do you identify a future challenge in your natural resources' availability? What could be the cause?