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Viticulture and Ecosystem Services: From Myths to Reality with Chilean Vine Growers

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VITICULTURE AND ECOSYSTEM SERVICES: FROM MYTHS TO REALITY WITH CHILEAN VINE GROWERS

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Résumé d'auteur

Plan indicatif	Introduction – Mise en scène – Problématique – Matériel et méthodes – Résulats &, 2, 3 – propositions pour le programme Vin, Changement Climatique et Biodiversité – analyse critique de la méthode - conclusion

RESUME

Ce mémoire s'est effectué dans le cadre du programme de recherche universitaire appliquéé « Vin, Changement Climatique et Biodiversité », coordonné depuis 2008 par des chercheurs chiliens en coopération avec les plus grosses entreprises viti-vinicoles du Chili et visant à protéger les écosystèmes natifs des régions de climat méditerranéen de l'expansion de l'agro-industrie. L'étude menée visait à rassembler et comparer les savoirs scientifiques et empiriques au sujet des services écosystémiques appliqués à la viticulture, en interaction avec les pratiques viticoles identifiées dans le contexte chilien. L'étude a consisté en une revue littéraire de trente articles du monde entier sur le sujet ; suivie de vingt-et-un entretiens semi-dirigés avec les viticulteurs des vignes partenaires du programme. Les hypothèses suivantes ont structuré l'étude 1) il existe des différences entre les savoirs scientifiques recueillis dans la revue littéraire et les savoirs empiriques récoltés lors des entretiens au sujet des services écosystémiques et de leur intégration avec les pratiques viticoles. 2) la variation des savoirs empiriques entre les viticulteurs pourrait être expliquée par leur paradigme productif, défini comme la qualification personnelle de l'ensemble des pratiques qu'ils appliquent sur les vignes sous leur responsabilité (conventionnel, biologique, biodynamique, intégré). Les résultats ont été comparés à travers d'un diagramme conceptuel représentant les services écosystémiques en interaction avec les pratiques viticoles. Le nombre de mentions pour chaque service écosystémique et chaque interaction service – pratique considérés a été compté lors de la revue littéraire puis à l'issue de l'analyse des entretiens. Il est représenté sur le diagramme à l'aide d'un ajustement de la taille des flèches. La discussion des résultats issue de la comparaison des deux diagrammes obtenus a mané aux conclusions suivantes : les services écosystémiques et interactions les plus mises en valeur par les deux approches (littérature et entretiens) sont les mêmes. Des différences complémentaires ont été identifiées entre les savoirs scientifiques et empiriques, qui ont permis d'identifier plusieurs axes de recherche futurs pour le programme Vin, Changement Climatique et Biodiversité. Si le paradigme productif définit de claires différences dans certains des choix de pratiques effectués par les viticulteurs, comme la fertilisation ou la gestion des adventices, il semble avoir peu d'influence sur bien d'autres pratiques viticoles. La perception globale des viticulteurs sur leur vignoble ne semble pas liée à leur paradigme productif, alors qu'elle exerce une grande influence sur leur manière d'intégrer la notion de services écosystémiques dans leur gestion du vignoble. Une recherche approfondie sur ce sujet, ainsi que le développement des axes proposés permettra au programme Vin, Changement Climatique et Biodiversité de générer de nouveaux savoirs adaptés à l'application du concept de services écosystémiques à l'échelle locale, ayant un impact direct sur les comportements des viticulteurs envers les écosystèmes natifs, ainsi qu'un engagement plus franc des vignobles partenaires pour la conservation de la biodiversité native des écosystème chiliens de climat méditerranéens. .

AUTHOR SUMMARY

AUTHOR : Garance JOURNET
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Key words: ecosystem services, viticulture, Chile, conceptual map, biodiversity conservation, agroecology

Indicative plan	Introduction – setting up the scene – problematic – Methdology – Results (part 1, 2 and 3) – propositions for the WCCB project – critical analysis of the method – conclusion

ABSTRACT :

This thesis work was led in the context of the Wine, Climate Change and Biodiversity program, coordinated since 2008 by Chilean researchers in cooperation with the biggest wine-making firms of the country and aiming at protecting the chilean native biodiversity from the chilean central mediterranean climate biomes from the agro-industry expansion. It aimed at gathering and comparing the existing scientific and experiential knowledge about the Ecosystem Services concept and its application in interactions with the different viticulture practices identified in the Chilean vineyards context. A literature review of thirty articles from the whole world and 21 semi-structured interviews were led with the viticulturists from the partner firms of the host program. Results analysis were structured around the hypotheses that 1) a knowledge gap separates the scientific knowledge collected in the articles from the experiential knowledge gathered throughout the interviews and 2) the variation of experiential knowledge between the viticulturists could potentially be explained by their management paradigm, defined as their personal qualification of the practices they apply on the vineyards they are managing. Results were compared using a conceptual diagram where the number of mentions to each ES and interaction were emphasized. Both approaches most valued the same ES. If the management paradigm defines clear differences in the viticulturists' choices for some practices, like fertilization and weeds management, it has a reduced influence on many other practices. The global perception that viticulturists have of their vineyards doesn't necessarily rely on their management paradigm, while it highly influences the way they integrate natural ecosystems and the ES in their practices. The complementarity of the two approaches also permitted to identify several potential research topics for the Wine, Climate Change and Biodiversity program to generate locally appropriate knowledge with direct impact on the viticulturists' behaviour towards native ecosystems and further involvement in native biodiversity conservation.

Table of content

I. INTRODUCTION

The current degradation of world's ecosystems, largely due to the expansion of a form of agriculture encompassing high environmental damages, has created a divorce between the paradigms of food and agricultural commodities production and the conservation of native biodiversity in natural ecosystems (Tilman, 2001). The current growing manifestations of global change and its obvious threats to humanity welfare (Cardinale et al., 2012) generates growing awareness of the urgent need to reconcile the objectives of feeding a growing human population while preserving the integrity of natural ecosystems with the biodiversity they host (Brussaard, 2010; Tilman et al., 2011). The progressive emergence of the concept of Ecosystem Services (ES) on the academic scene, defined as "the direct and indirect benefits people receive from ecosystems"(Millennium Ecosystem Assessment, 2005; Danley and Widmark, 2016) introduced a new era for academic research, enhancing interdisciplinary approaches to design tools adapted to tighter cooperation with the policy makers in order to try and reverse the trend of global and climate changes (Turner et al., 2016). Nevertheless, there is urgent need for locally-adapted, stakeholders based tools to introduce the enhancement of Ecosystem Services in land-use management in countries where regional to national land-use management policies are less developed (de Groot et al., 2010; Müller et al., 2011). The recent evolution of Chilean land use, dominated by the massive conversion of large private lands towards industrial agricultural and forestry activities (Armesto et al., 2010) gives a striking example of the conflicts and the discrepancy between the paradigms of modern agriculture and biodiversity conservation (Viers et al., 2013). In particular, the central Mediterranean-climate regions of the country named among the worlds' biodiversity hotspots (Myers et al., 2000) are undergoing massive land-conversion from natural ecosystem to croplands for counter-seasons products and wine production, hence increasing the emergency of cooperating with local land-owners to ensure the conservation of the Chilean native Mediterranean ecosystems (Cox and Underwood, 2011).

The Wine, Climate Change and Biodiversity project, founded in 2008 by a group of Chilean biology and ecology researchers, applied the ES concept to the Chilean Mediterranean climate context in order to increase awareness and research for the conservation of a highly endemic biodiversity at local scale. The team has been increasingly successful in generating conservation initiatives among Chilean vineyards through the development of an applied research agenda coupled with an environmental education program.

The program is reaching a crossroads in its development, looking for new ways to further involve the vineyards in native ecosystems conservation efforts on their properties. The next step for the WCCB project consists in opening the dialogue with the partner vineyards on the

integration of ES in their daily viticultural practices within their vineyards agroecosystems, recognizing and valuating the importance of native landscape for this objective.. Viticulture management conditions the way biodiversity and ES are integrated in the vineyards. While most of the modern, large scale viticulture consists in virtual monocrops relying on high inputs of fertilizers, pesticides and herbicides, the recent emergence of organic, biodynamic and sustainable ways of growing vines has been accompanied by the diversification of viticultural practices, while wine-makers claim drastic reduction of their environmental impact (Tompkins et al., 2012). Being in interaction with all of these types of vineyards, the WCCB team question reliability of the management paradigm as an indicator of actual integration of the ES and the biodiversity in the vineyards management. In this context, the mission of this agroecology thesis is to build bridges between the perception of the WCCB actors and the partner viticulturists, ranging from academic ecology, applied conservation sciences and concrete viticultural experience.

This study thus aims at leading a first exploratory investigation about the existing knowledge of the ES applied to the vineyards contexts and their interactions with different viticulture practices. It will adopt a comparative approach between academic knowledge and the experiential knowledge of the viticulturists involved in the WCCB project. The work will thus be separated in two steps: a literature review on the subject of ES application to vineyards will be led in a first time, followed in a second time by semi-structured interviews with 21 viticulturists from the WCCB partner vineyards. Both activities will pursue the objective to understand the definition and applications of the ES concept in the context of the vine-growing activity. Results will be synthetized and analysed on the base of a visual diagram in order to facilitate the comparison between the two steps of the study, as well as to ensure the easy transfer of the results to the partner vineyards. The filter of the management paradigm will be used to look at eventual variations of the perception and the actual integration of the ES concept to the partner vineyards. Discussions about the similarities and differences identified between the different sources of knowledge and among viticulturists may lead to the identification of future lines of research for the WCCB project in cooperative with their partner vineyards.

II. SETTING UP THE SCENE

Being both agroecologist and member of a research laboratory led by ecologists, the ongoing debates about the future of agriculture and biodiversity conservation has a central place in this thesis reflection. The coming paragraphs aim at setting up the conceptual framework that surrounds the existence of the “Wine, Climate Change and Biodiversity” (WCCB) program and the origin of their interests for agroecology.

II.1 From global change to global need for change

II.1.1. GLOBAL CHANGE

The multiple crises Humanity undergoes for some decades raised the awareness on the need to re-invent new ways of being in relationship with the Earth. During the 1980s, the International Geosphere - Biosphere Program defined the concept of Global Change as "planetary scale changes to atmospheric circulation, ocean circulation, climate, the carbon cycle, the nitrogen cycle, the water cycle and other cycles, sea-ice changes, sea-level changes, food webs, biological diversity, pollution, health, fish stocks, and more" (IGPB, 2016). In 1987, the Brundtland report underlined for the first time at an international policy level the urgent need to acknowledge the anthropogenic sources of a global change at a human-lifetime scale and drew the attention of international policy makers towards the need for concrete decisions aiming at the sustainable development of societies. According to the panel, sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" (our common future 1987, pt.27). The emergence of this new objective on the international scene opened a new page of research, to both assess the multiple manifestations of the Anthropocene and propose solutions for the transition towards a sustainable development (Foley, 2005; UNO, 2016).

II.1.2. AGRICULTURE, LAND USE CHANGE AND BIODIVERSITY LOSS

The modern way of developing agriculture and food-industry, based on the 1960s green revolution (Evenson and Gollin, 2003), has since then been every time more questioned (Balmford et al., 2012a). The fast and constant increase of the world population together with the simplification and standardization of diet increased dramatically the demand for a few agricultural raw materials, resulting in the development of a highly contaminating agroindustry, major land conversion and deforestation in the southern countries accompanied by genetic simplification and biodiversity loss over the past decades (IAASTD, 2009; Wright et al., 2012).

Therefore, the worldwide agricultural activities, including the conversion of new agricultural lands, are responsible for around 30% of the global emissions leading to global warming (IAASTD, 2009). Currently, as the southern countries enter in a developing period, the global net increase of demand for agricultural products, and in particular meat, leads to the rapid conversion of natural ecosystems into intensively farmed-land where reduced to no room is left for biodiversity. Estimations of native ecosystems loss at global scale due to land conversion for intensive agricultural use from 2000 to 2050 is of one billion hectares (ha), which represents more than the surface of the United States of America (Tilman et al., 2011). This land-conversion is mainly occurring in the southern developing countries of Africa and South America (Tilman, 2001). Current trend of agricultural development in these countries is

privileging intensive agricultural methods leaves reduced room for local biodiversity to survive on agricultural land (Cardinale et al., 2012; Foley, 2005; Tilman, 2001). Together, the agricultural intensification, natural habitat fragmentation due to land conversion and anthropogenic climate change are part of the main drivers of the greatest massive species extinction ever experienced on the earth, currently happening (Plotnick et al., 2016; Thomas et al., 2004). The most appropriate lands for agriculture being the most biodiverse at the same time, a strong opposition is being made in the land-use paradigms between production for human development, and biodiversity conservation (Perfecto and Vandermeer, 2010).

II.2 Agroecology within the food industry

II.2.1. ECOSYSTEM SERVICES: FIRST STEPS TOWARDS A RECONCILIATION OF PARADIGMS?

Since the 1990, the emergence of the "ecosystem services" (ES) concept, defined as "the services that humans receive from the Ecosystems" (Millennium Ecosystem Assessment, 2005) brought a new perspective on the role nature plays in human activities, revealing the profoundly intertwined character of human well-being and both managed and natural ecosystems' good functioning. In particular, the ES concept drove a shift in human perception of Nature, from being perceived as an entity completely apart from human reality to the whole complex body intertwined with humans, as shown in figure 1 (Mace, 2014):

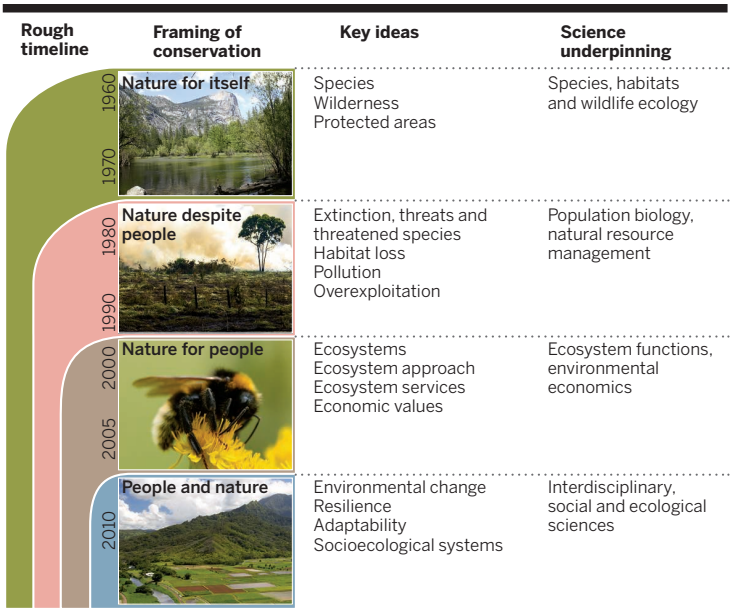


Figure 1: *Changing views of nature and conservation. Over the past 50 years, the prevailing view of conservation has changed several times, resulting, for example, in a shift in emphasis from species to ecosystems. None of the framings has been eclipsed as new ones have emerged, resulting in multiple framings in use today (extracted from: Mace, 2014)*

This shift led to a new era for both conservation and agricultural sciences. It is now globally acknowledged that the scientific research has to adopt new holistic approaches to tackle the multiple and tightly intertwined issues linked to environment and agriculture (Holt-Gímenez and Altieri, 2013; IAASTD, 2009; World Commission on Environment and Development, 1987; Wright et al., 2012). The introduction of the ES concept changed profoundly the ways of studying and assessing land-use evolution and its impact on human welfare. It generated a dramatic increase of the knowledge about the biophysical interactions linking biodiversity with the ecological processes supporting ES, while increasing the awareness on the impact of agriculture on biodiversity and the ecological processes, as shown in figure 2 (Banerjee et al., 2013):

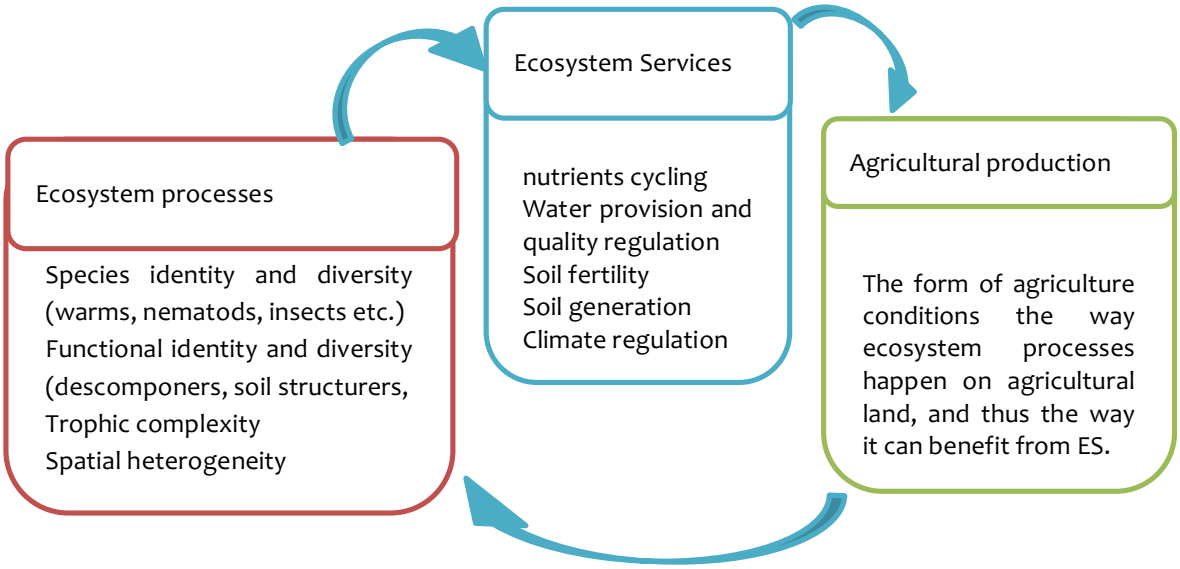


Figure 2: *Linkage between biodiversity, ecosystem processes, services and agricultural production: agriculture can be perceived as the receiver and the provider of ecosystem services in a (adapted from de Groot et al., 2010 and Le Roux et al., 2009)*

In parallel, the development of a diversity of tools to give a monetary value to the provision of ES by natural ecosystems (Sandhu et al., 2015), or to calculate the costs linked to the ecosystems degradation and the resulting loss of ES (Costanza et al., 2014) resulted in a growing awareness of the importance of integrating natural ecosystems in the land-use management from local to global scales (Turner et al., 2016). Other tools were hence developed to represent the evolution of ES provision under different landscape-management scenario, mostly directed to policy makers (de Groot et al., 2010). These changes set the bases for a possible reconciliation of paradigms between productivity and biodiversity conservation under the common objective of sustainable land use.

II.2.2. ES APPLICATIONS TO AGRICULTURE: THE DEFINITION OF AGROECOLOGY

The progressive integration of the ES concept by agronomists is leading to a change in their perception of the biodiversity: they understood the importance of considering more than the mere agrobiodiversity (gathering the selection of species introduced or sawn in an agricultural land (FAO, 2016)), as its dynamics and structure are the support of key ecosystem functions generating the ES (Le Roux et al., 2009). Namely, the ES application to agricultural sciences awakens the interest for agroecological methods, substituting synthetic inputs by manipulations at the landscape and plots scales to enhance the natural flow of key ES such as the nutrients provision to the plants, the soil regeneration, the regulation of the water flow and the control of pests populations and diseases propagation (Altieri, 2014; Gliessman, 1990). As shown in figure 3, agroecosystems form a gradient from fully converted, intensively cropped land providing a precise type of agricultural product, to semi-natural ecosystems providing agricultural products as well as a bundle of other ES (Rist et al., 2014):

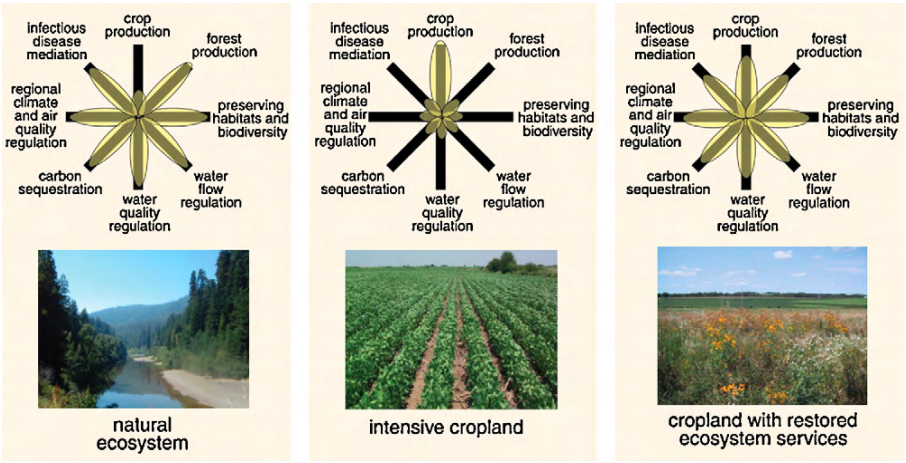


Figure 3: *Influence of a gradient of human intervention on a bundle of Ecosystem Services happening in a landscape (source from Foley, 2005)*

Hence, according to their integration of different levels of non-cropped biodiversity, agroecosystems can or not be considered as the providers of ES (Power, 2010; Wratten et al., 2013). Agroecological practices can even restore degraded ecosystems, where key ecological processes leading to ES provision and increasing overall biodiversity are reestablished (Duru et al., 2015; Rist et al., 2014; Swinton et al., 2007). Therefore, the emergence of an agroecology approach to agriculture and biodiversity conservation is generating an evolution of the vision of production and conservation paradigm, from a strict separation towards an integrated third way based on the enhancement of an integrated landscape management where low-impact agricultural and natural ecosystems form win-win interactions and allow to reach both sustainable food production and biodiversity

conservation goals (Balmford et al., 2012b; Brussaard, 2010; Francis et al., 2004; Tscharntke et al., 2012; Wezel et al., 2016; Wright et al., 2012). Some example of agroecological restoration of degraded natural ecosystems exist in the tropical areas, they are fewer in the Mediterranean climate where equal urgent need for biodiversity conservation was identified (Myers et al., 2000; Schulz et al., 2010)

II.2.3. AGROECOLOGY PRINCIPLES: ES ENHANCEMENT AT ALL SCALES IN ALL FORM OF ECOSYSTEMS

The enhancement of ES at all scales of the landscape requires agroecologists and biodiversity-conservationists to develop coordination tools and skills of with a wide diversity of stakeholders. Francis et al. establish a clear distinction of the different scales where changes of flows, actors and issues occur, illustrated in figure 4:

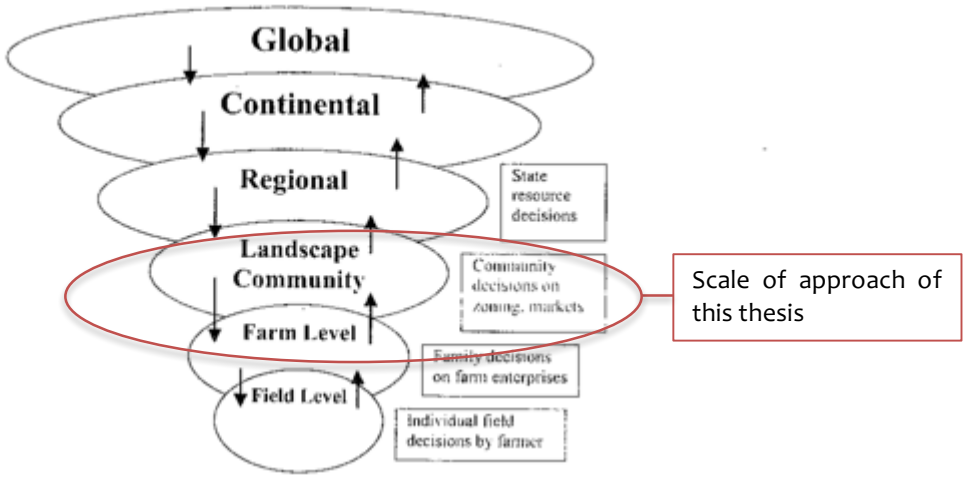


Figure 4: *Spatial hierarchy of scales for decision making (from Francis et al., 2004)*

The transition towards a landscape management enhancing biodiversity and agroecological production can be applied to small producers as well as for big industries. It lies on the consideration of the principles presented in figure 5 (Altieri and Rosset, 1996):

Agroecology principles applied to the farm level

- Increase biomass recycling and balance nutrients flow
- Ensure soil quality through maintaining a high organic matter content and an active soil biological activity
- Minimize the loss of resources (nutrients, water, genetic resources, biodiversity)
- Diversify the genetic of species at farm and landscape scales
- Enhance biological interactions and synergies
- Establish an ecological-processes based agriculture

Figure 5: *Agroecology principles to apply at farm scal. Each principle refers to the enhancement of one or several ecosystem services.. The last principle establishes a clear link between agricultural activity and ecological processes (source: (Altieri, 2014)*

The lack of application tools of these concepts at the “farm” (or private land unit) and landscape levels makes the generation of concrete changes in landscape management through the conceptual framework of ES difficult (de Groot et al., 2010; Müller et al., 2011). This is particularly acute in the countries with weak corporate land-management policies, where most of the power on landscape-management decision concentrates in the hands of the land owners.

This study, led in the Chilean central region context, is embedded in this conceptual framework and proposes a participation to a local project of cooperation between university researchers and the Chilean wine sector, gathering a considerable power on land management in a region where the conflict between urgent need for biodiversity conservation and the attractive land conversion to lucrative intensive agricultural activities is under high tensions.

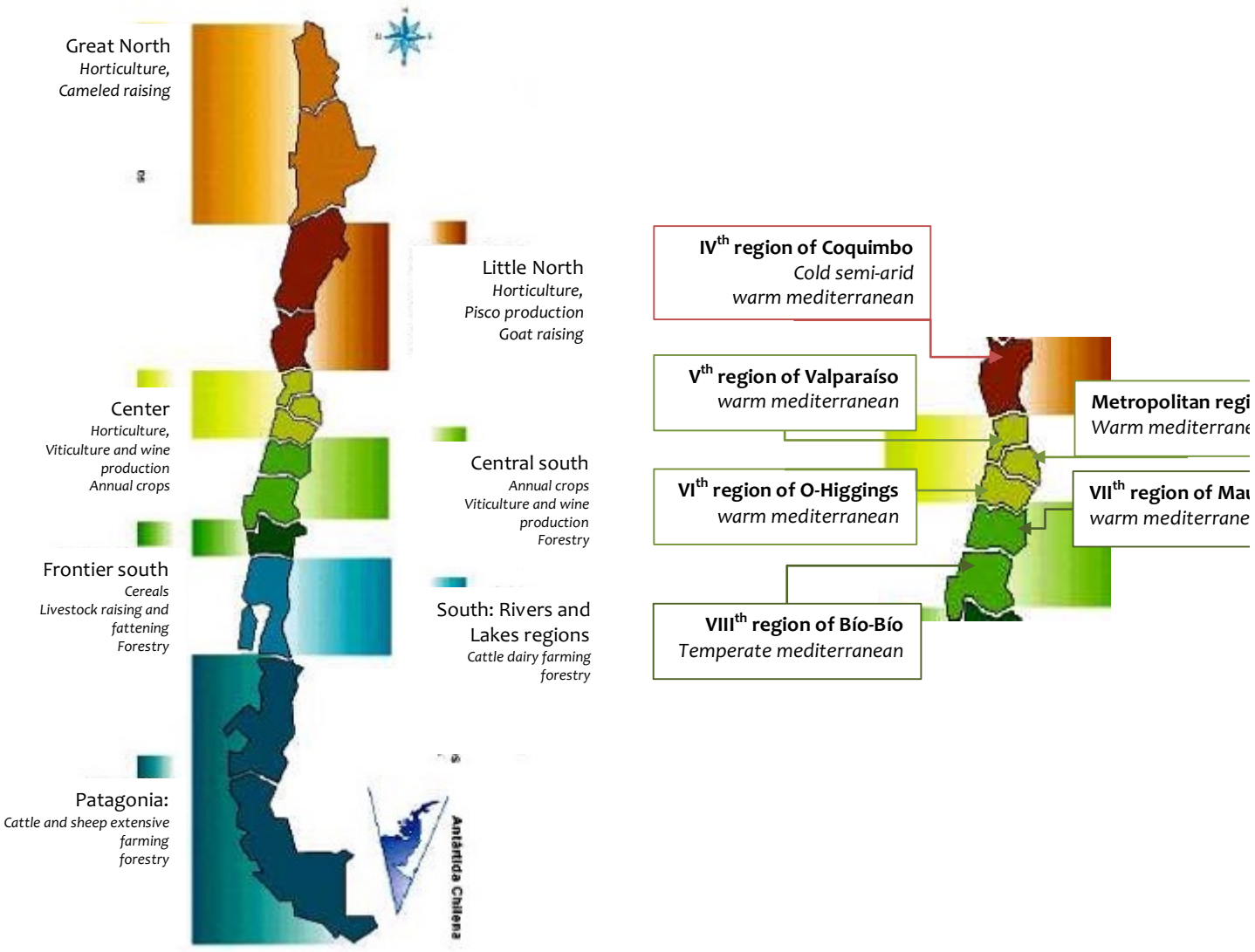
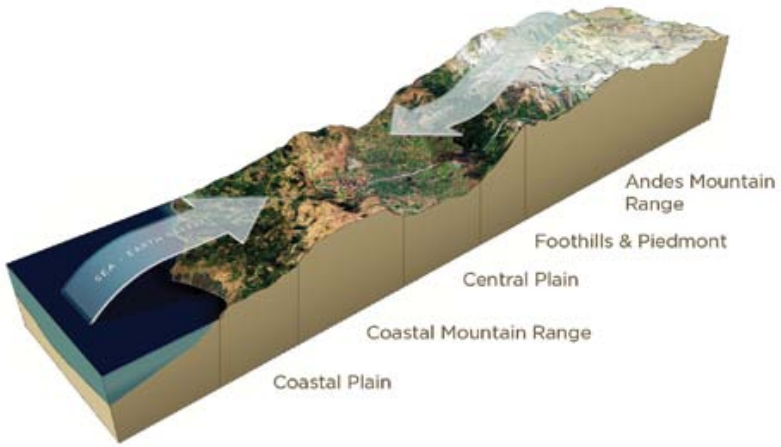


Figure 6: *Map of Chilean main agricultural activities (FAO, 2006) and zoom on the Chilean Mediterranean-climate regions*



Source: Origo Ediciones

Figure 7: *Structure of the Chilean central valley and its climatic influences*

II.3 Chilean case: climate change, agricultural expansion and biodiversity conservation

II.3.1. GEOGRAPHICAL CONTEXT:

Chile is a long and narrow country of the south-eastern extreme of South-America. surrounded by two mountain ranges in the eastern (the Andes) and western (the coastal range) side, the world's driest desert in the north and the Patagonian glaciers in the south. The people and the agricultural activities concentrate in the central lowlands (figure 6 front page, centre to Rivers and Lake regions).Considered as one of the most developed countries of the continent, Chile's economic dynamism relies mainly on its mining and agricultural activities (Gobierno de Chile, 2010). The country based its economic growth on a geographical division in "clusters" of industrial development, ranging from mining in the north to forestry in the south or exportation agriculture in the central area. Several natural advantages set the conditions for the agricultural productivity of the country:

- Chilean geographical situation is similar to an island in term of biological and ecological flows: it is totally isolated from its neighbours' pests and diseases. This makes it a privileged arable land, protected from many plant-health issues faced by the rest of the world (Gil and Pszczolkowski, 2007)
- Chile's central regions (centre and central south in figure 6) are among the rare template Mediterranean climates of the southern hemisphere. Moreover, the presence of the Andes and the coastal mountain range create a cooler climate in the central valley, making the cultivation of multiple crops possible even during the prolonged summer droughts (figure 7). These regions concentrate the production of counter-season fruits exported to the northern hemisphere.

II.3.2. LAND REPARTITION AND AGRICULTURAL GROWTH

Chile is nowadays the 17th main country on the world food trade market. The Chilean food sector represents 10% of the national GDP (Pro Chile, 2015) from which 39% is exported, mainly to the United States, Europe, Japan and China (Worldbank, 2016). Chile mainly produces and exports grapes, apples, wine, kiwis, cereals and other counter season fresh fruits (Pro Chile, 2015). The establishment of a free-market for lands and the adoption of a neo-liberal economic model since the dictatorship years (1973 – 1990) enhanced the concentration of land ownership, accelerating dramatic changes in Chilean land-use and agriculture (Armesto et al., 2010): in 2007, 2% of the agricultural land-owners gathered more than 70% of the agricultural lands (Instituto Nacional de Estadísticas, 2009). On the one hand, this situation enabled Chile to easily integrate the global food market, filling the niche-markets of highly standardized products for the occidental countries ("FAOSTAT," n.d.; Instituto Nacional de Estadísticas, 2009). On the other hand, the fast and unregulated growth

of the agricultural and forestry sectors is happening at the cost of most of the native ecosystems' areas (Armesto et al., 2010).

II.3.3. CHILEAN MEDITERRANEAN ECOSYSTEMS: AGRICULTURE AND BIODIVERSITY HOTSPOT

The Mediterranean climate regions are of particular interest for both conservation and agriculture in Chile. Characterized by wet and humid winters and a prolonged drought season in the summer, they host at the same time more than 50% of the Chilean vascular plants and vertebrates' biodiversity in the diversity of semi-arid to humid sclerophyllous vegetation forms (figure 8) (Cox and Underwood, 2011) , 83% of the fruitcrops (SNA, 2007) and the almost totality of the vineyards for wine production (ODEPA, 2015).

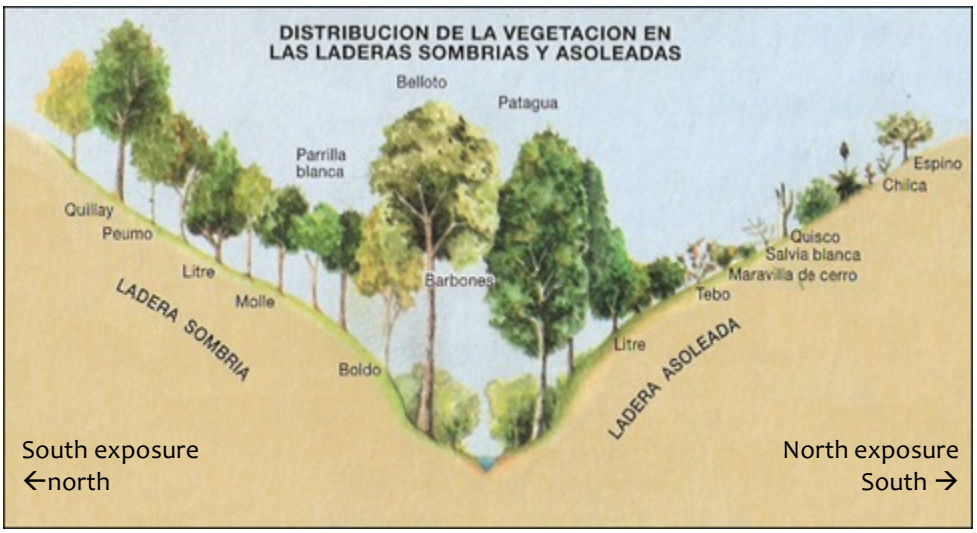


Figure 8: *Distribution and diversity of the vegetation on the Chilean Mediterranean hillsides (Mediatecacl, 2016)*

Figure 9 shows the constant and fast growth of these last two sectors, generating major land conversion and natural habitat loss (Hannah et al., 2013):

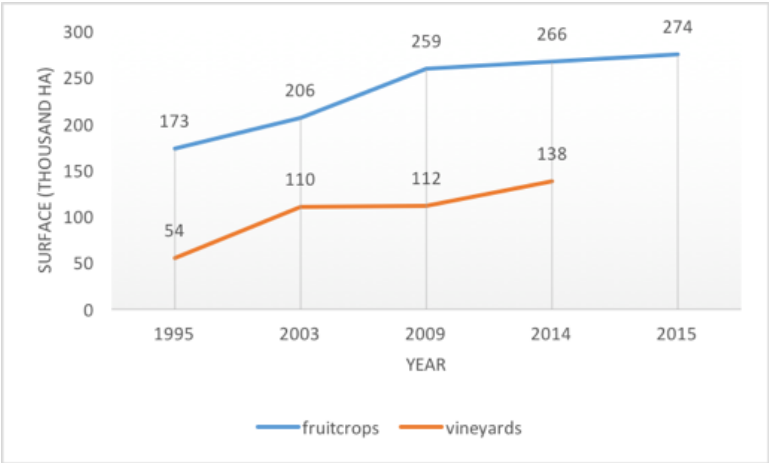


Figure 9: *evolution of the planted surfaces of vineyards and fruitcrops in the chilean mediterranean region (own elaboration, datas from:(ODEPA, 2015)*

As a result of the geographical isolation and the unique geo-climatic conditions, 30% of the biodiversity of these ecosystems is endemic, thus placing them among the “biodiversity hotspots”, defined by Myers et al. as “areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat” (2000, p. 853). Until now, the Mediterranean regions are the less covered with protected areas. Figure 10 shows that contrary to the other regions, less than 1% of the Mediterranean region is protected:

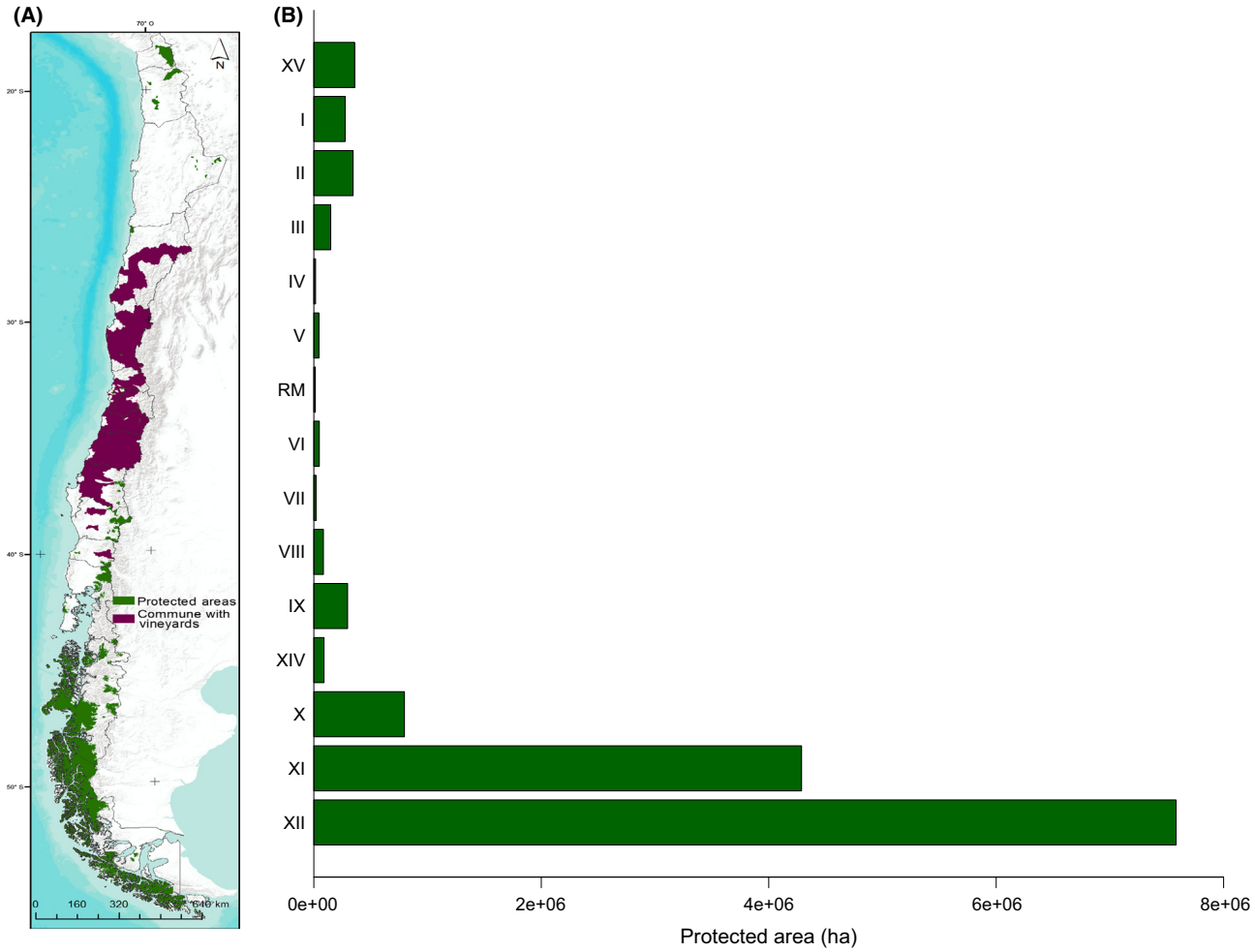


Figure 10: *Map of Chile (A) showing vineyards (in purple) and protected areas (in green) and their respective total area in each administrative region (B), which are represented by Roman numerals and ordered from north to south (extracted fromCastañeda et al., 2015)*

Moreover, most of the lands are under private property regime, making the creation of new protected areas more difficult at the regional and national scales and reinforcing the necessity for conservationists to base their efforts on the cooperation with the local private land owners (Cox and Underwood, 2011)

II.3.4. CHILEAN AGRICULTURE: SMALL DOESN'T MEAN BEAUTIFUL

In the Chilean farming systems, small and local doesn't necessarily rhyme with qualitative, tasty and healthy: contrary to its neighbours Bolivia and Peru, Chile doesn't count on a rural network rooted in indigenous traditions, but rather on a mix of practices relying on chemical inputs with a gradient of mechanization level, from very low to very high (Faliès, 2008).

Chile maintains its colonial tradition of large private agricultural properties oriented towards exportation agriculture (Faliès, 2008; Muñoz et al., 2007; Instituto Nacional de Estadísticas, 2009). The country went through a massive rural exodus phenomenon over the past decades, which emphasized the abandonment of small scale agricultural activities in the countryside and reinforced the concentration of the land-tenure (Faliès, 2008).

The collapsing of all the public organizations for agricultural development during the dictatorship period, together with the opening of the country to foreign capitals resulted in the development of a network of private consultancy services in the whole rural area, often backed up by international agrochemical firms (Belfor Portilla, 2000). Conventional agricultural practices, based on the use of external seeds and inputs, are thus common both in the small and big production units while organic agriculture is still marginal and mostly applied in the context of exportation farming (Aguayo, 2011). Furthermore, the interest for sustainable agriculture appeared very recently in Chile, emphasized by the increasing demand from international trade and environmental organizations (Faliès, 2008; Campos Medina, 2012). The ministry of Environment exists since 2010 but still shows rare contacts with the agricultural ministry, leaving the sustainable production initiatives to the willingness of the producers (Campos Medina, 2012; Aguayo, 2011).

Nevertheless, within the country, the organic market is still marginal and environmental awareness still very low in the Chilean people's mind. Thus, the sustainability incentives mostly come from big agricultural firms, oriented towards exportation. For example, the organic certification is delivered by exclusively foreign organizations to almost exclusively big farms, for its high economical cost and the level of organization and education required to cope with its requirements slows down its adoption among the small producers of the country (Aguayo, 2011).

II.4 A picture of the Chilean wine sector

II.4.1. MAKING AND DRINKING WINE: A CHILEAN HABIT?

The wine was introduced at the same time as Christianism in Chile: brought by the first religious communities in 1550, vines soon became a common element of the family farm in the rural area (Gil and Pszczolkowski, 2007). The national production of wine was pushed by the export market since the XVIIIth century and has been raising dramatically since the 1990s,

resulting in a doubling of the planted surface from 1980 and 2010 (figure 9, see page 11). Nevertheless, drinking wine has always been associated to a wealthy social class in Chile and the inner wine consumption therefore stays low: 17 L per capita in 2015 according to the Global Agricultural Information Network, compared to 55L in Argentina and 40 L in France (2015, p. 2), and more than 60% of the wine produced is exported as bottled or bulk wine to Europe (mainly UK), the USA and Asia (Mainly China) (Global Agricultural Information Network, 2015; Gil and Pszczolkowski, 2007).

The development of Chilean viticulture has thus never been driven by the local demand, but is rather the fruit of the work of nostalgic European immigrant in a first time and the globalization of the wine consumption over the last decades.

On the production side, most of the vineyards grow “fine wine” European varieties needing irrigation devices: Cabernet Sauvignon, Chardonnay and Sauvignon blanc being the most planted(ODEPA, 2015). The “casual” varieties, often typical from Chile and thus more resistant to drought such as the “país” red wine grape or the “Moscatel de Alejandría” are mostly planted in dryland vineyards by medium to small scale producers and rarely reach the requirements of volumes and quality for exportation (Gil and Pszczolkowski, 2007).

The resulting wines are classified according to the varieties used, the type of vinification and the time of conservation before commercialization ranging from “varietal”, “Reserva”, “gran reserva” up to “premium” wines. Until now, in order to seduce the occidental taste, the viticulture and vinification methods applied in Chile are imported from Europe and the USA (Muñoz et al., 2007). Typically, the big wineries today use to importing French or American oak barrels for the maturation of their wines instead of making their own ones with local wood. Therefore, it is possible to say that wine making and drinking is not a Chilean habit yet, and rather follows impulses and traditions from abroad (Gil and Pszczolkowski, 2007; Muñoz et al., 2007).

II.4.2. CHILEAN VITICULTURAL LANDSCAPES

Vines grow in Chile in an extended area, from the heart of the Atacama Desert to the rainy hillsides of the Osorno Valley (figure 11):

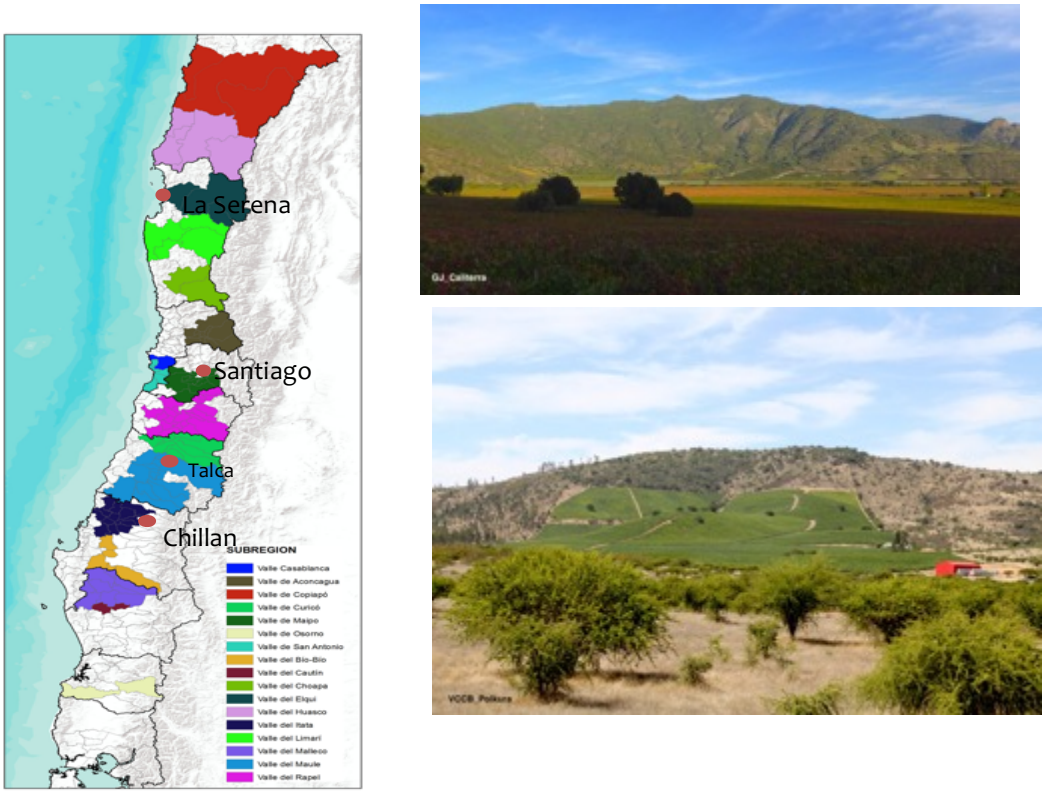


Figure 11: *The Chilean wine valleys (Gobierno de Chile, 1994) and vineyards landscapes of Colchagua, Curicó's valley (VIth region)*

Nevertheless, figure 12 shows that the almost entire viticulture for winemaking concentrates in the central Mediterranean area:

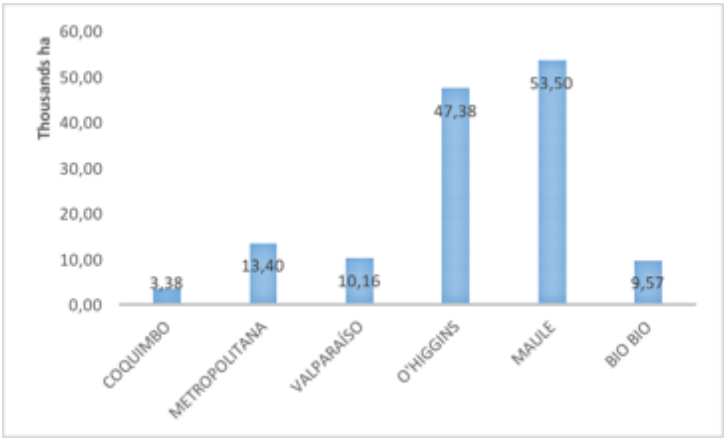


Figure 12: *Vineyards surfaces in the Mediterranean regions of Chile in 2014*

The vines are planted either in the central valley, surrounded by the coastal mountain range in the west and the Andes chain in the east, or within the coastal mountain range, proposing a wide diversity of soils' types. The Chilean viticulture is traditionally divided in two types: the irrigated (77% of the planted surface), and the dryland vineyards (23% of the planted surface)(Gil and Pszczolkowski, 2007). This last type of vineyard is mostly present in the southern part of the viticultural area within the coastal mountain range, and represents the small producers who often don't afford the installation and running costs of irrigation. The balance between vineyards and native vegetation is relative on the size and situation of the vineyards: most of the time, the vineyards located in the central valley, where most of the land has been converted, are more similar to "monoculture fields" surrounded by other monocrops or urban areas, whereas the vineyards located on the hillsides of the Andes or into the coastal chain are more likely to be surrounded by native vegetation due to the low conversion of the land, slowed down by the topography.

II.4.3. IMPULSES AND ACTORS

The wine production follows the pattern of Chilean agricultural development: more than 60% of the national production is exported while the five main wine making firms concentrate more than 50% of the total exported volume, with 40% ensured by the biggest company on its own (Gil and Pszczolkowski, 2007). Muñoz et al. divide the Chilean wine producers in two main families (2007) :

- the big wineries, owned by large land owners and mostly receiving international capitals. They are characterized an average of 100 ha planted with fine vine's varieties and the use of infrastructures and production methods at the cutting edge of technology. They are the drivers of current growth of the planted surfaces and wine production. On the international scene, they are represented by the trade union organization "Wines of Chile", gathering 90 of the 8000 Chilean wineries since 2007 .
- the small producers, characterized by small planted surfaces (30 ha in average), and the lack of access to sufficient technology and knowledge to produce their own wine (Muñoz et al., 2007). They thus have to sell their grapes to the big wineries or produce wine in a artisanal or even clandestine way, selling their wine to the local illegal market.

More recently, some small or medium-scale independent wine-producers are emerging and gaining the local and international wine markets. They are the drivers of a new wine production and consumption style, enrooted in the emerging concept of "Chilean terroir". This emerging family formed since 2009 an independent organization called "MoVI" (Movement of Independent Winemakers), gathering ambassadors of a new identity for the Chilean wine opposed to the concentration of the sector (Movimiento de Viñateros Independientes, 2016).

II.4.4. CLIMATE CHANGE AND ECONOMIC DEVELOPMENT: THE WINE SECTOR AT A CROSSROADS

The Chilean wine producers are currently torn apart between the opportunity of further development of their production to satisfy international demand and the already noticeable changes linked to the global change. On the one hand, temperature evolution and shortage of water as consequences to Climate Change threaten almost 47% of the current vineyard area in the country (Altieri, 1999; Gliessman, 1990). Despite the opportunity to compensate by planting in the southern regions, overall loss is expected to be a 25% of current surfaces (Hannah et al., 2013). On the other hand, the progressive appropriation of the "terroir" concept by Chilean wine makers make them more sensitive to key ecosystem services like soil formation and stewardship (Arresi, 2015). Besides, the already existing water provision issues in the Mediterranean regions, together with the international and national demands for sustainability and transparency and the obvious marketing advantages linked to a "green production" generate greater environmental awareness among the winegrowers (Viers et al., 2013). Paradoxically, most of the Chilean viticulturists conserve a production paradigm based on the use of external input in order to maximize their productivity and very few institutional incentives and information are available about ways of making compatible the production goals with the protection of native biodiversity and the prevention of climate change. Under the influence of international retailers, the consortium Wines of Chile published a "sustainability code" in 2009, giving guidelines for the members to get higher environmental involvement in their viticultural and wine-making processes (Santiago-Brown et al., 2014b). The Chilean wine sector is therefore at a crossroad, where the wine growers themselves express their need to develop their industry towards a more sustainable model (Hannah et al., 2013; Viers et al., 2013; Castañeda et al., 2015; Arresi, 2015). The Wine, Climate Change and Biodiversity program presented hereafter understood and ceased this opportunity to start enhancing biodiversity conservation practices within vineyards by the wine-growers themselves.

II.5 Wine, Climate Change and Biodiversity program

The WCCB program is one of the rare research projects in Chile where scientists, working in ecology and conservation, base their work on the tight cooperation with the local industry. Both research and educational activities pursue the objective of better understanding the relationships between the ability of natural ecosystems to provide ecosystem services to the viticulture and winemaking industry and their vulnerability to climate and land use change over the next decades.

II.5.1. INTERUNIVERSITY, INTERDISCIPLINARITY, INTERNATIONALITY

These are the leading characteristics of the team carrying out the WCCB program, which current dynamism relies on a wide network of professionals motivated by the same will of generating concrete evolutions of the Chilean biodiversity conservation efforts:

- The WCCB program is being led by a team of ten researchers within the Institute of Ecology and Biodiversity (IEB), a Chilean "virtual" research centre gathering researchers spread in the whole country around the study of Chilean biodiversity. The IEB is mainly funded by public grants delivered by the state. It remains the main source of funding for the project.
- The WCCB team is composed of ten researchers and punctual students from very diverse backgrounds. Started by ecologists and biologists, the integration over time of environmental education specialists and sociologists enriched considerably the relationship with the partner vineyards, enabling the team to reinforce their integrative approach of education and research and to achieve concrete changes in the wine sector while creating new scientific knowledge.
- Finally, the program is an active member of the international collaboration network integrated by researchers and wineries involved in conservation programs throughout the Mediterranean biomes. Current partner projects are located in California, Baja California, South Africa and Australia. Collaboration results in collective publications and punctual journeys to exchange and understand each-other's realities.

It is noticeable that the WCCB program only constitutes half of Olga Barbosa's research activities and covers the employment of the program's coordinator Karina Godoy as well as a postdoc renewed every two years. The other team members, interns and researchers, voluntarily participate in exchange of minimal defrayal for their involvement.

II.5.2. APPLYING SCIENCE TO « REAL WORLD »: THE WCCB – VINEYARDS' PARTNERSHIP

18 wine-making firms from the central regions are currently cooperating with the WCCB program: half of them are large-scale and highly hierarchical multi-national firms managing more than 500 ha of land in the different Chilean valleys; the other half rather structured as Small and Medium Enterprises with simpler organization and less land. The partnership with the vineyards starts at the signature of a contract between the WCCB team and the vineyards' contact person (often the responsible for sustainable development, or the agricultural manager), committing the vineyard to actively cooperate to all the research and pedagogic activities proposed by the program; while the program commits to supply

pedagogic support and staff, research material and results. The concrete cooperation is based on a one-day workshop carried out within each firm at the beginning of the partnership. The workshop is proposed to the integrity of the vineyards' staff, from its general managers to the field-employees. It is divided into two main steps:

- In the morning, researchers present didactic versions of their studies about the impact of climate change on viticulture and ways to adapt and mitigate it at the vineyards' scale, as well as basis about conservation of Chilean native Mediterranean biodiversity. A practical activity about scientific investigation protocols and methods closes the first part of the day.
- In the afternoon, a participative workshop is proposed on the field, inviting the participants to vision the implementation of conservation practices on their vineyards. The participants are divided in teams and use a map of the field they are on to draw their proposal. Some teams are provided with unlimited time and money resources, while the others have to include limited resources in their planning. The workshop ends with an open discussion about the concrete conservation resolutions that could be easily implemented on the properties of the winery.

After the workshop: a book about conservation practices, written by the WCCB team is handed in to the viticulture managers, while constant availability of the researchers is ensured to answer questions about the implementation of conservation practices at any time after the workshop. Moreover, complementary services are proposed to the vineyards, such as biodiversity inventories or the design of pedagogic track sends on the vineyards' properties for touristic use. As a consequence, most of the vineyards who took the workshop implemented conservation practices on their properties, while a total of 25,002 ha within the vineyards' properties are now under protection measure (Márquez Garcia, 2016).

II.5.3. GENERATE SCIENTIFIC KNOWLEDGE TO REINFORCE THE IMPACT ON AGRICULTURE

Nourished by the growing number of participating vineyards, following topics could already be tackled by the researchers within the program:

- The realization of the first map representing all the land of the country belonging to wineries, differentiating the already planted surfaces and the potential conservation areas within the properties. This research emphasized the importance of generating awareness and will for biodiversity conservation among the Chilean wine makers while allowed the program to target vineyards with high conservation potential.
- The study of the microbial diversity within the vineyards and in the surrounding Mediterranean ecosystems focuses on showing evidence of the participation of native

ecosystems to wine's typicality and quality. A first research project was led, proposing a comparison of the soil microbial communities in the vineyards and the surrounding sclerophyllous ecosystems in different valleys (Castañeda et al., 2015).

- Currently, the PhD student Roland Sanchez studies the possible participation of native yeasts provided by the sclerophyllous ecosystems to the wine-fermentation process.
- the study of native herbaceous species through the prism of their functionality as cover crops (green manure, soil structuring, allelopathy) in order to replace the exotic species currently sawn in the inter-rows of the vineyards. This research is being led in partnership with a specialist in organic viticulture and some of the partner vineyards.
- The pedagogic efficiency of the program was evaluated by PhD student Marcela Márquez-García, who assessed visits the impact of the program on the partner vineyards' conservation practices through several questionnaires, in depth interviews and field. Marcela's work already enabled to restructure the educative workshop in order to reinforce its participative component and strengthen the empowerment of the vineyards staff in the conservation initiatives.
- Karina Godoy, the coordinator of the program, is currently pursuing her Msc in rural development. her thesis work is based on the WCCB network, trying to study the development of an innovation network about conservation practices within the Chilean wine-making industry.

II.5.4. THE WCCB AT A CROSSROAD

Today, the program has reached reasonable fame and counts on the participation of the biggest wineries of the country, having growing influence on the key stakeholders for a considerable part of the potential protection areas identified at first. These first years of work gave promising results, awakening environmental awareness and building strong relationships of mutual trust and respect with the partner vineyards. More recently, Olga Barbosa could launch a dialogue with both the Ministry of Environment and the Ministry of Agriculture about the need to commonly develop incentive policies for conservation of the Mediterranean ecosystems. Besides, Phd Marcela Márquez did major findings about the partner's perception of biodiversity conservation practices: biodiversity is considered as a major asset for the corporate image of the vineyards, bringing strategic advantages and strengthening the links to tradition (Márquez-García and Jacobson, 2015). Nevertheless, few links were made by the viticulturists between the conservation practices and the chore of their viticultural practices. They expressed a clear desire to get more evidence of the concrete benefits of ES for wine quality and viticulture activity, as well as their difficulties to

identify their concrete application at the vineyard's scale (Márquez Garcia, 2016) Moreover, the first results of the microbial communities' studies showed the possible impact of the viticulture practices on soil microbial composition, both observing changes in communities composition and suggesting the provision of ecosystem services such as nutrient inputs from the forest to the vineyards (Castañeda et al., 2015).

These last findings show the obvious need of the WCCB team to open a new page in their research and in the dialogue with their partner vineyards, expanding their expertise beyond the mere conservation practices while responding to their partner's desire to better link the conservation of native biodiversity with the production activity that remains the centre of their work. Understanding the dynamics and constraints linked to the wine grapes production and having an overview on the way viticulturists actually perceive and manage their agroecosystem and its surrounding ecosystems is a necessary step before launching any efficient and purposeful research. In order to reach these new goals while maintaining their initial activity, the WCCB team needs to increase their working force.

III. PROBLEMATIC.

Following paragraphs will detail the elements and expectations that built the chore reflection of this thesis work.

III.1 Give a better overview of the present of Chilean viticulture to help WCCB team visioning the future of the program

III.1.1. UNDERSTAND WHAT ARE THE CURRENT VITICULTURE PRACTICES OF THEIR PARTNERS

The next key step for the program consists in better understanding the viticultural practices applied by their partners. Indeed, impressions arising from the previous findings are that there is a gradient of viticulture practices from "conventional" practices with high negative impact on the native biodiversity to "organic" practices with lower impact, or even positive impact on the native biodiversity. Working with a diversity of vineyards made them aware that the "management paradigm", defined as viticulturists' qualification of their production methods, that may be supported by certification, may actually not reflect this gradient of practices. For example, the study of microbial communities revealed that practices such as sulphur application against damaging fungi, widely used in biodynamic to conventional Chilean vineyards, may have a strong inhibition impact on the soil fungal biodiversity and thus on the soil regeneration processes (Castañeda et al., 2015). The team also noticed that the phytosanitary costs of some conventional vineyards inserted in a complex landscape with very low pest pressure could be lower than those of some organic vineyards planted in a simpler landscape more similar to monoculture (personal discussions with the team, 2016; supported by Tscharntke et al., 2005). Clearing this understanding would enable them to

adapt their indicators of the impact of viticulture practices on the native biodiversity and on the resulting ES.

III.1.2. ASSESS VITICULTURISTS' KNOWLEDGE ABOUT ES PARTICIPATION TO THEIR PRODUCTION PROCESS

Each new research project of the program is perceived as an occasion to further integrate the partner vineyards in the investigation process. Previous assessment works focused on the perception of the same actors of the benefits of biodiversity conservation (Márquez Garcia, 2016). The natural following step is thus to investigate how the stakeholders understand the ES and their interactions with viticultural practices within their own vineyards, in order to identify the points of knowledge to be clarified about the potentials of ES and biodiversity conservation. This will enable the program team to better orient their research in order to increase the partners' understanding and interest in native biodiversity conservation.

III.1.3. TRANSFERABILITY OF THE FINDINGS

The WCCB program cultivates a transparent relationship with its partners. The team thus always set the transferring of new scientific findings to the vineyards as a priority. This attitude already permitted most of the partner vineyards to overcome the still strong prejudices about academic research and made them become more open to the team's solicitations for participation in a research project over time. One of the conditions of this thesis project is thus the adaptation of the findings to a visual support of presentation easy to transfer to vineyards in a short time after the results arise.

III.2 Thesis objectives

The objectives of this thesis for the WCCB team is to propose a review of the current viticulture practices applied by the partner wineries, confronting it with the classical "production paradigm" classification while exploring the current knowledge of the viticulturists about the ES and their interactions with the viticultural practices. The results should be presented in a way that transfer to the partners will be easy and simultaneous to the results' publication.

In other words, this thesis work will aim at answering following questions:

- What is the state of the art of the empirical knowledge about the interactions between viticulture practices and Ecosystem Services?
- How do the stakeholders of the viticulture department of the WCCB's partner vineyards define the ES at their vineyard's scale and which interactions do they identify with their viticulture practices?
- Confronting the vision of viticulturists and the empirical knowledge: what are the common points and differences between the two and among the viticulturists'

approaches? Is the management paradigm of the viticulturists a potential factor of variations among the viticulturists' understandings and integration of the ES concept?

Following hypothesis were formulated at the starting point of the thesis:

- There is a gap between empirical knowledge and actual awareness of the viti-viniculture stakeholders about the interactions between Mediterranean Ecosystem Services and viticulture practices.
- The stakeholders of the partner vineyards express a different perception of the interactions between viticultural practices and Ecosystem Services provided by the Chilean Mediterranean natural ecosystems according to their production paradigm: the vineyards matching to organic and biodynamic requirements are more aware of these dynamics than the staffs applying integrated or conventional viticulture methods.

This thesis pursues following main objectives:

- Identify the most relevant Ecosystem Services to consider in the Chilean viticultural context and propose a classification of viticulture practices enhancing their interactions with the selected ES.
- Collect and list the practices applied on the vineyards working with the WCCB program.
- Assess the knowledge that the key stakeholders of the partner firms have about the concept of ES, its application to their vineyards and how ES interact with their viticultural practices.
- Confront the empirical knowledge with the collected "practical" knowledge of the stakeholders, give potential explications of the variation of knowledge between the stakeholders and the potential gap with empirical knowledge.
- Use a visual and simple tool to present and compare the results of the different research steps.

The objectives will be fulfilled through following steps

1. A literature review of the scientific and grey literature about the links between viticulture practices and ES will first be carried out. It will enable to establish the state of the art of the empirical knowledge about the subject and to propose a classification of the viticulture practices in order to enhance the visualization of their interaction with key ES. The results of the review will be discussed in the study context and synthetized on a conceptual map.

2. Interviews of the viticulturists and agricultural managers of the WCCB partner vineyards will be carried out in order to find out how they define the concept of ES and how they link it to their practices. The interviews will be transcribed and analysed on the base of the conceptual map built in step 1.

3. Results of the literature review and the interviews will then be confronted to draw conclusions about the influence of production paradigm in the way viticulturists define the ES concept and perceive the interactions between their practices and the ES.

These three steps will be presented in three separated results sections. The conclusions drawn in the two first sections will be confronted and discussed in the third section.

IV. MATERIAL AND METHODS

IV.1 Ecosystem services and Viticulture: a review

IV.1.1. REVIEW METHOD

The review of existing literature and projects about the integration of Ecosystem Services within the wine-making sector constituted the first step of this study. The review was led using google scholar, key words were “Ecosystem services”, “viticulture practices”, “vineyard management” and synonyms. The choice to select articles only explicitly mentioning the concept of Ecosystem Services was made to reduce the selection to 30 articles on the topic and fit in the ambitions of this study. The detailed list of the articles considered is available in appendix xx. It encompasses twenty scientific papers, two theses, three practical guides addressed to viticulturists, two reports of research seminars and three chapters of scientific research books. The different ES mentioned in the literature were listed and summed. This work led to the selection and classification of the ES treated in this thesis. Each ES identified in a paper was crossed with the definition proposed by de Groot et al. (2010) in order to ensure coherence in the classification. Likewise, all the interactions between ES and specific viticulture practice or set of practices was counted and total interactions were summed. This information served as a base for the qualitative analysis and the comparison with the interviews.

Readings led to two parallel reflections: how different approaches of ES among the wine-making countries influences their progressive integration in the viticultural practices on the one side; the scientific findings sustaining evidence of ES participation to the grape-growing process and of their interactions with the viticultural practices on the other side. The Chilean state of advancement in these two reflections was finally discussed, enhancing key-elements for further study and valuation of ES in the national wine-making industry.

IV.1.1. CLASSIFICATION OF THE VITICULTURAL PRACTICES

There is no consensus on a classification of the viticulture practices adapted to the consideration of all the ecosystem services: as the interactions between practices and services are multiple and intertwined, most of the scientific studies about viticulture and ES focus on a precise set of them. Besides, the way people perceive and value ES is highly depending on their local social and cultural context. While viticulture practices may vary according to the local production context, the grape-production cycle and the general viticulture practices are constants worldwide. Reynier separates the viticultural practices in five functional categories: the soil management, the fertilization, the yield management, the vine's pests and diseases management and the vineyard's landscape management (2016). Based on this work, the categories presented in table 1 were set up for this study:

Practice	Description
Yield and canopy	control of the vine's vigour and grape yield
Inter-row soil cover	soil cover management: bare soil / permanent or temporary use of vegetal cover (natural pasture or cover crops)
Inter-row soil labour	tillage / no tillage, decompaction practices
Harvest	harvesting methods (manual or mechanical)
Fertilization	Management of vines' nutrition
Under-vines / Weeds	Management of the weeds and soil under-vines.
Pests and diseases (P&D)	Methods of control of invasive and harming species in the vineyards
Irrigation	Methods of water captation and spreading into the vineyards
Land conversion	Decision to replace non-cropped ecosystems (with variable presence of native species) in order to plant new vineyards
Landscape elements	management of non-cropped species (native or / and introduced) within and around the vineyards.
Cattle	Use / prohibition of domesticated animals within the vineyards' property

Table 1. Description of the classification of the viticulture practices used in this study

This classification integrates small variations of the original one, as the studies read in this review made a clear separation between practices interrows and undervines and between soil cover and soil labour. The irrigation, land conversion, cattle and social categories were added after the interviews to adapt to the Chilean vineyards' context.

IV.2Conceptual-mapping:

IV.2.1. DEFINITION AND JUSTIFICATION OF THE TOOL

The results of the review were summarized through the elaboration of a "conceptual diagram" summing up and classifying the rich amount of information manipulated. Eppler (2006) defines the method as "a systematic depiction of an abstract concept in pre-defined category boxes with specified relationships, typically based on a theory or model" (p. 203). In this case, the diagram represents the ES applied to current Chilean viticultural landscapes and their potential interactions with the viticultural practice. The different elements of the vineyards' landscape and the practices are represented with rectangles; the ES and the interactions with arrows. Figure 13 gives an overview of the structure of the diagram.

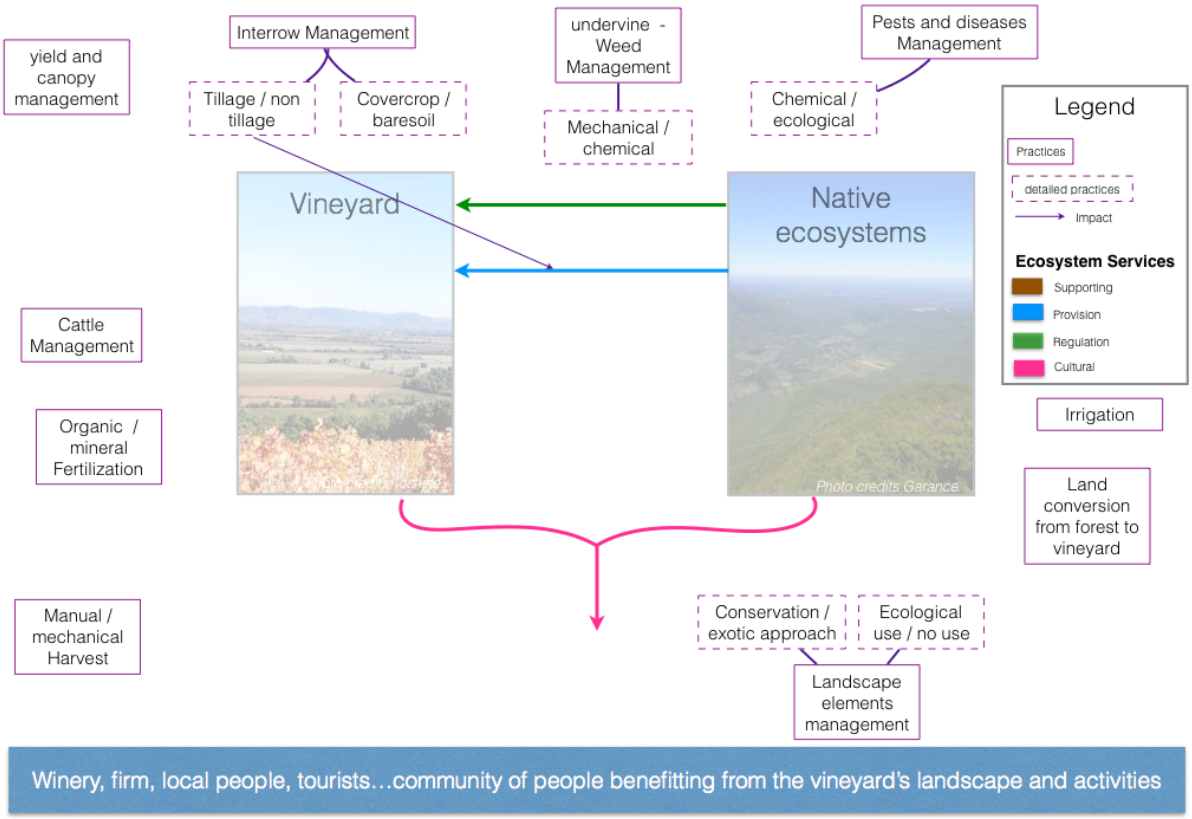


Figure 13: *Structure of the conceptual diagram representing the ES applied to Chilean vineyards' landscapes.*

This methodological choice was made for following reasons:

The ambition of taking into account all the ecosystem services and all the practices at stakes in the vine-grape production requires a multi-scalar working tool, dealing with a diversity of elements and concepts, some very concrete and other very abstracts, resulting in a complex and multifactorial situation. Using mapping methods enables to clarify the reflection without simplifying it (Armson, 2011)

- The objective of the qualitative interviews following this first step is to understand and represent how the partner vineyards' managers define and apply the ES concept in their production context; and which interactions they identify between their viticulture practices and the ecosystem services they receive. The conceptual diagram served as the framework to classify the information collected in order to easily identify the common points and differences of knowledge between the stakeholders and the theory, and among stakeholders.
- Natural affinity for mind mapping was shared from the beginning with the working team, this work aims at testing the ability of this tool to both provide valuable information for the program and a visual, easily understandable way of presenting the results of a research project to a public not used to classical academic writing as the vineyards' staffs are.

IV.2.2. ANALYSIS INTEREST

the conceptual diagram was established during the bibliography research. Its elaboration was based on the definition of a conceptual diagram according to Eppler's classification (2006). The diagram was reproduced after each interview, selecting the ES and the interactions identified by the viticulturist, resulting in 21 individual maps. This method was inspired by the mental maps mentioned in Elsawah et al., 2015, where the researchers synthetized the flow of thoughts of the interviewee about the research topic in order to get a visual representation of the interviewee's vision. In the case of this study, the diagram fitted the format of the initial conceptual diagram instead of illustrating the actual flow of thoughts of the interviewee.

Two final diagrams were edited at the end of this study, where the relative importance of each ES and each interaction identified in the literature and the interviews were illustrated with following method: the font-size of the ES arrows were differentiated into three categories, the font-size of the interaction arrows were differentiated into five categories according to the number of papers (or viticulturists) quoting them: the biggest arrows represent the most quoted and the thinnest the less quoted. Besides, the viticulturists' map encompasses new arrows, representing interactions that were not identified in the literature.

IV.3Semi-structured interviews with the vineyards agricultural managers

IV.3.1. POPULATION INTERVIEWED

21 semi-structured interviews were led in a second time with the partner vineyards' staff involved in all the decisions linked to viticulture management. The Chilean wine-making industry being a quite closed universe, the population of study was defined within the boundaries of the WCCB project, selecting the firm's staffs involved in all the viticulture decisions. Official solicitation letters were sent to ten of the partner vineyards having regular contacts with the program. Most of the partner vineyards being large-scale firms with complex hierarchical structures, at least two persons at different hierarchical steps were interviewed in each of the nine vineyards who responded to the solicitation. The tight relationships between actors and crossed experiences make fine statistical analysis impossible, thus confirming the mere qualitative nature of this study. The interviews were led during a ten-days trip to three different wine-making valleys in the Vth and VIth regions and in Santiago. They took place in the offices or on the field of the professionals, half of them in the presence of Karina Godoy, the administrator of the WCCB program. Interviews were recorded and integrally transcribed. There length varied from 21 minutes to 1 hours 38 minutes. Despite the variable length, the same topics were tackled in all the interviews. The interview-guide and an example of transcribed and coded interview are available in appendices II and III.

IV.3.2. ANALYSIS OF THE INTERVIEWS

A codebook was set up detailing the different topics that were tackled during the interviews. The code encompasses two to three coding levels. Following main topics were distinguished:

- Personal position: information about the person's experiences and opinion, responsibilities in the firm, personal definition of the Ecosystem Services concept.
- Management paradigm: description of the overall production methods, use of certifications.
- Practices: description of the different viticultural practices applied to the field(s) under the responsibility of the person.
- Ecosystem Services: direct or indirect identification of ecological processes serving the vine-grape production.
- Relationship: identification of a link between one or a set of practices with one or a set of Ecosystem Services.
- WCCB: confirmation of participation to the program's biodiversity workshop, comments about the program

- Actors: external actors mentioned during the conversation involved in the enhancement of Ecosystem Services in vineyards.

Interviews' transcriptions were then separated in paragraphs according to the order in which the topics were tackled. The information was condensed and summed up in excel sheet, were refined lecture enabled to apply a second and third detail levels. Results were analysed using qualitative lectures of the information. The code book is available in appendix IV.

V. RESULTS STEP 1: VITICULTURE AND ECOSYSTEM SERVICES, A LITERATURE REVIEW

V.1 Introduction

Current challenges and opportunities of development of the Chilean wine sector increased the receptivity of the wine industry actors to some reflection about solutions to mitigate climate change while optimizing their production costs and meeting their yield's objectives on the long run (Arresi, 2015; Hannah et al., 2013). The concept of Ecosystem Services applied to viticulture can help moving the reflection forward as it can be used as a tool to reinforce the consideration of viticulturists for the natural ecosystems within and around their vineyards. Indeed, the identification of key ES and the proposition of concrete adaptations of practices to better integrate them at the vineyard's scale can result in major economical savings for the viticulturists, while reducing dramatically the environmental impact of viticulture (Orre-Gordon et al., 2013; Sandhu et al., 2016). There is growing literature about ways to enhance Ecosystem Services within vineyards, but few studies support the concrete application of the ideas proposed in the theory (Le Roux et al., 2009; Orre-Gordon et al., 2013). The adoption of the ES conceptual framework to study of vineyards agroecosystems seems to be a relative new approach, as most of the into the articles reviewed in this study are dated after 2010. Based on the review of 30 articles from Europe, New-Zealand, Australia, South Africa, the USA and Chile, this study aims at better understanding how the ES concept is being introduced into the viticulture sector worldwide. It will first focus on the identification of the most valued ES (among the MEA classification of Ecosystem Services) and the links made between them and the viticultural practices, summarized in a conceptual map representing the potential interactions between viticulture practices and ecosystem services in the Chilean context. It will then review the different approaches of the concept in the wine making countries, discussing their impact on viticulture practices in their regions or countries. Finally, the possible impact of management paradigm, defined in this study as the way viticulturist qualify their production methods, on the integration of ES as a production tool, will be discussed on the base of the readings.

V.2 Viticulture and ecosystem services: detailed review of actual and potential interactions

Detailed literature review of the different ES identified in the 30 articles, in interaction with the viticulture practices, is available in appendix V. Following paragraphs will summarize the findings.

V.2.1. ES IDENTIFICATION

The twelve ES shown in figure 14 were identified in total:

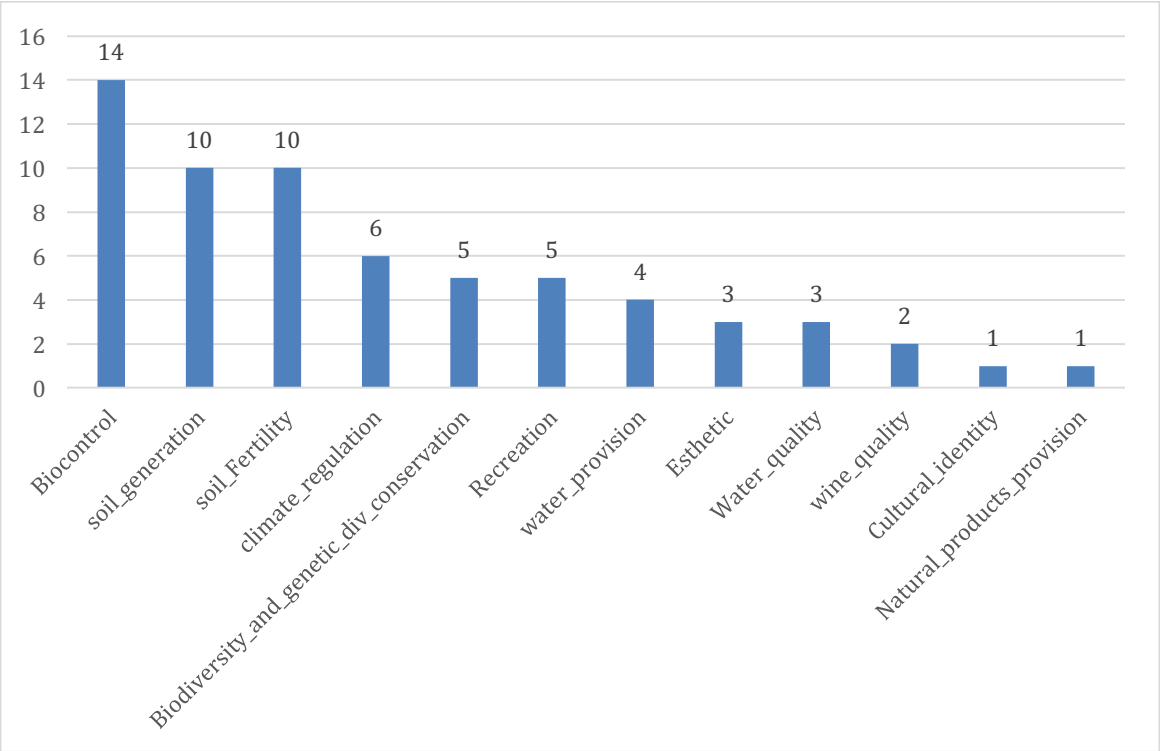


Figure 14: *Number of quotes of ES in the analysed articles*

They occur at different scales, some of them sustaining the wine-grape production, others resulting from the interactions between the viticulture activity and the natural ecosystems.

Tompkins et al. (2012) proposes a global view of the ES applied to viticulture, differentiating the ES provided to the vineyards and the ES resulting from the wine-making activity figure 15:

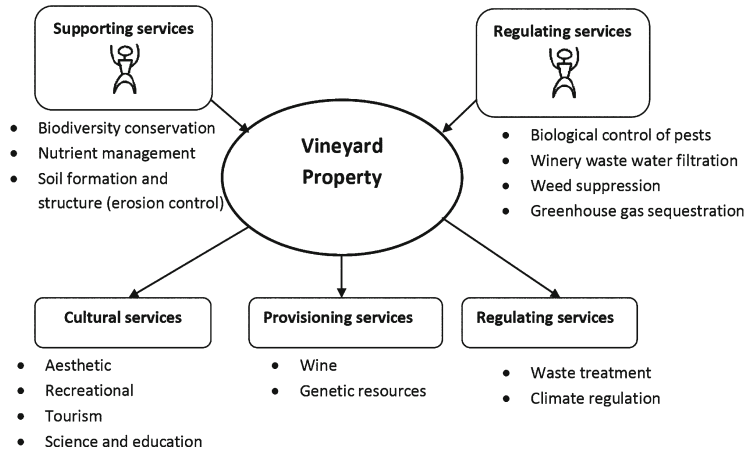


Figure 15: *the dynamics of ES in relation to the vineyards (extracted from: Tompkins et al., 2012) The human figure represents the potential for on-farm manipulations to enhance ES resulting from vineyard's activities.*

In this study, only the ES related to the vine-growing step were considered. Overall, the ES most valued in literature are services provided to the vineyard (Biocontrol, Soil generation and soil Fertility), directly linked to the production of grapes. They can be measured at plot and field scale. The services resulting from viticulture activities (aesthetic, recreational and cultural identity) and / or happening at landscape or regional scale (climate regulation, water provision and quality) are less considered. This may be explained by the fact that most of the articles considered in this study are scientific papers using the classical academic approach focused on one or a set of ES.

The Biocontrol ES is described in the articles as the regulation of the plant health conditions through either naturally happening or human induced ecological processes involving living organisms. It is largely described in the articles, its measurement being adapted to scientific methodologies and its potential financial value for viticulturists being high. The soil generation Ecosystem Service encompasses the ecological processes resulting in the formation and conservation of a soil structure and physical properties. It enables the good development of plants' roots and the easy infiltration of water, thus preventing erosion. The soil Fertility ES refers to the regulation of soil nutrients' cycling through biotic and abiotic processes. Tightly linked to soil life and organic matter content, it determines the availability of nutrients for the plants.

The soil generation and fertility conditions determine the way vine's root will penetrate and explore the soil in the search for water and nutrients (Castañeda et al., 2015; Lamastra et al., 2010; Pino Torres, 2013; Priori et al., 2015; Rochard, 2014; Salomé et al., 2015; Tompkins,

2010; Tompkins et al., 2012; Trouvelot et al., 2015), thus constituting an important part of the "Terroir" of each vineyard (Etcheverry, 2014). This last element may be a factor explaining the high interest for these two ES applied to viticulture. The terroir is defined as "a concept which refers to an area in which collective knowledge of the interactions between the physical and identifiable biological environment and applied viti-vinicultural practices, providing distinctive characteristics for the products originating from this area" (OIV, 2010). The increasing valuation of the terroir concept links to a growing consideration of the biodiversity and genetic diversity maintenance ES, still relatively few considered by the literature. Indeed, the knowledge and integration of the special bio-physical context of a precise place has a central importance in the creation and conservation of a terroir for the wine. This concept and the clear marketing asset it encompasses for the vineyards have constitute a major argument for native biodiversity conservation in the New-world wine making activity (Castañeda et al., 2015; Steel et al., 2017; Tompkins et al., 2012).

The climate regulation service is described at different scales in the articles: some consider it as a services at landscape scale benefitting to the vineyards (Etcheverry, 2014; Rochard, 2014; Tompkins et al., 2012), while others emphasize the vineyards's agroecosystems as potential global climate regulation agents (Brunori et al., 2016; Salomé et al., 2015; Tompkins et al., 2012) Interestingly, the literature from the "old world" wine-producing countries focus more on the climate regulation as a service generated by the vineyards than the articles based on new-world wine-making countries such as Chile or New-Zealand. This could be explained by the presence of more natural ecosystems around the vineyards in these countries compared to the old world vineyards. Water provision ES is perceived differently according to the wine-making regions: while being the result of the mere natural processes (rainfall and water flows) for the template and humid Mediterranean viticulture regions, it is the fruit of the interaction of humans with natural water flows to provide irrigation to the vineyards in dryer climates. The perennation of water provision ES is tightly linked to the need for irrigation. In Chile, where almost 80% of the vineyards surface are irrigated (Gil and Pszczolkowski, 2007), the pressure on water provision ES is very high. Indeed, in 2013 95% of the Chilean wine-making areas were already under water stress, generating the need to move the viticulture areas further south where water is still relatively abundant (Hannah et al., 2013).

Cultural ES, separated in aesthetic, recreational and cultural identity in this study, encompass the way people perceive and value the landscape formed by the vineyards and their surrounding ecosystems. Winkler and Nicholas affirm that cultural ES highly vary according to the wine-making region, taking multiple facets according to the cultural relation to landscape, the history of viticulture in the landscape and the way it is practiced in this

context (2016). Recreational ES were relatively more valued in the articles than the aesthetic and identity ES, maybe through the direct economic benefit that recreational activities can bring to the vineyards. The development of sustainable viticulture program all over the world enables to progressively introduce the cultural ES into the perception of the viticulturists. The wine quality is mentioned in very few articles. While the definition of terroir tightly links the wine quality to the bio-physical specificity of a vineyards (Tompkins, 2010; Wheeler et al., 2005), the link to the ES concept remains unclear in literature. Finally, the provision of natural products in addition to grapes in the vineyards landscapes is mentioned in only one article (Rochard, 2014). It is of secondary importance in this very specialized sector.

V.2.2. INTERACTIONS OF ES WITH VITICULTURE PRACTICES

Figure 16 shows the interactions between ES and viticulture practices mentioned in the 30 studies reviewed in this study:

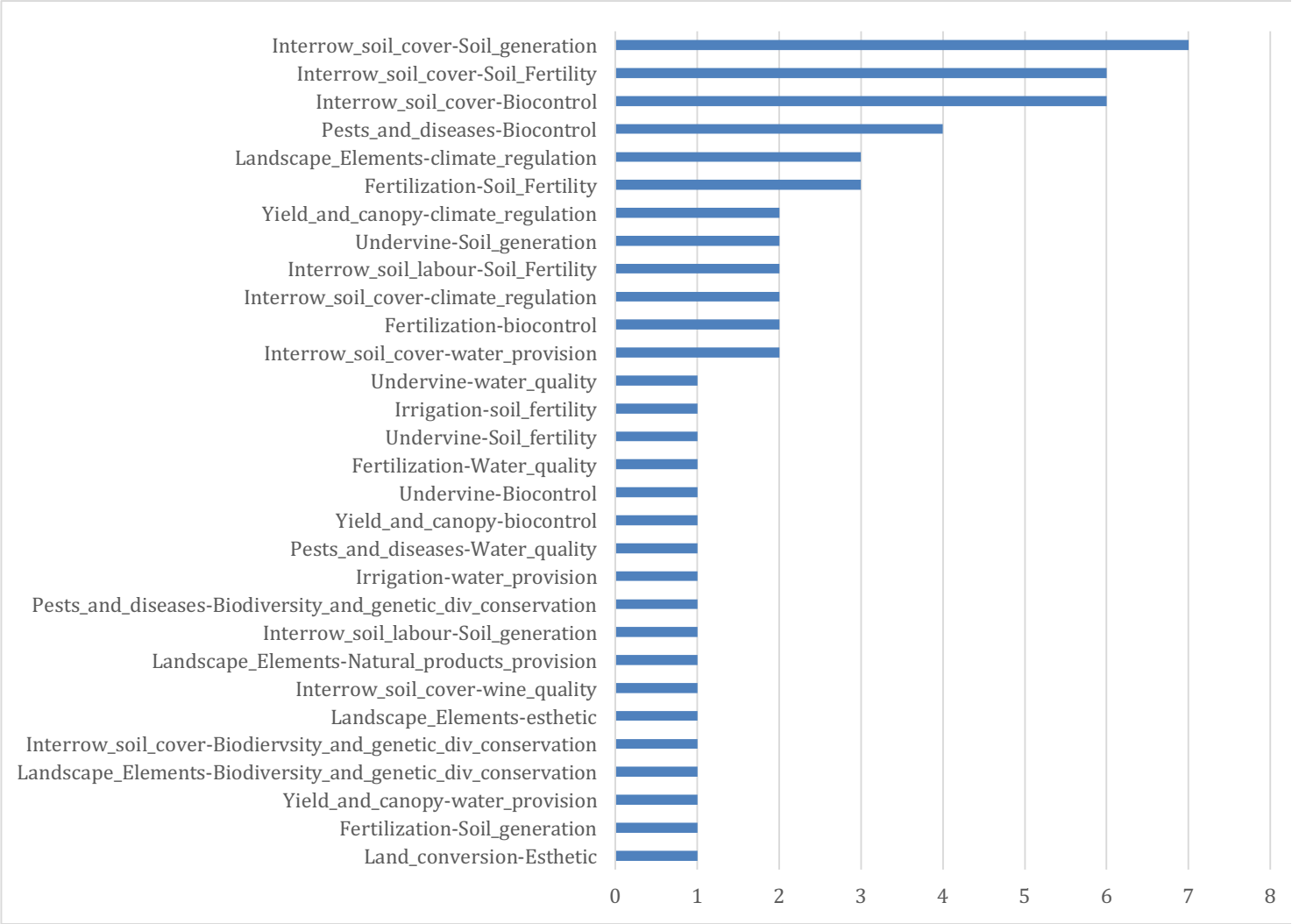


Figure 16: *Number of quotes for each Relationship identified between ES and viticulture practices*

Different types of interactions were identified according to the study: may it be the positive or negative impact of a given practice on an ES or the integration of an ES in a management strategy. The interaction most emphasized is the relationship between the management of non-cropped species on the vineyard, called “landscape elements” in this study, and the biocontrol ES. the landscape elements category gathers the vegetal biodiversity present within and around the vineyards. In this category, some articles emphasize the use of a controlled biodiversity known to attract beneficial fauna in the form of ecological corridors or flowering strips, while others emphasize the general enhancement of natural biodiversity on the vineyards as a source of phytosanitary balance in the field. The latter interaction is however mostly advocated as a side-recommendation which doesn’t constitute the central point of the study. The implementation of cover-crops on the vineyards’ inter-rows is emphasized as an innovative practice with high potential to enhance a bundle of ES (Brunori et al., 2016; Danne et al., 2010; Etcheverry, 2014; Lamastra et al., 2010; Orre-Gordon et al., 2013; Pino Torres, 2013; Rochard, 2014; Salomé et al., 2015; Sandhu et al., 2016; Tompkins et al., 2012; Trouvelot et al., 2015; Webb et al., 2011; Wheeler et al., 2005; Whitelaw-Weckert et al., 2007). The studies of Danne et al. (2010) and Tompkins et al (2012) about the potential of native herbaceous species is of particular interests in the WCCB context. The use of synthetic inputs for fertilization, weeds, pests and diseases management is also regularly regarded as potentially slowing or replacing the natural occurring of key ES such as Biocontrol, soil fertility and soil generation (Altieri and Nicholls, 2002; Castañeda et al., 2015; Etcheverry, 2014; Lamastra et al., 2010; Orre-Gordon et al., 2013; Rochard, 2014; Salomé et al., 2015; Sandhu et al., 2016; Tompkins et al., 2012; Trouvelot et al., 2015; Whitelaw-Weckert et al., 2007).

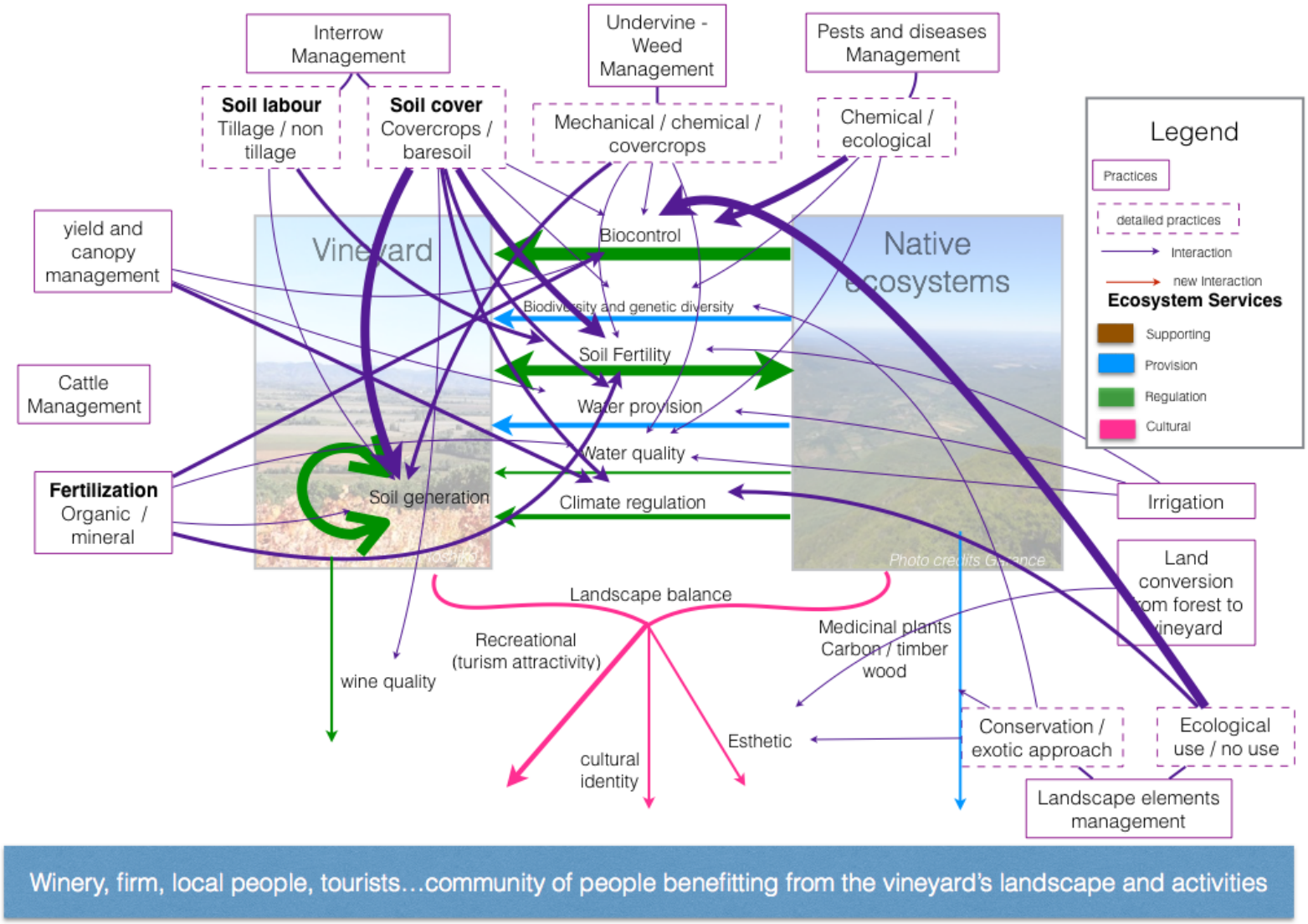


Figure 17: *Interactions between Viticulture practices' and Ecosystem Services occurring in Chilean vineyards: a conceptual diagr*

V.2.3. GATHERING ES AND INTERACTIONS: A CONCEPTUAL DIAGRAM

The findings of this literature review were summed up and presented in the conceptual diagram in figure 17 (see front page). The diagram represents the flows of ES within a vineyard's property as thick coloured arrows. The goal of the WCCB project being to show evidence of the ES provided by the local natural ecosystems to the viticulture and wine-making activities, particular attention was paid to clearly represent the native ecosystems. The majority of entering ES flow from the native ecosystems to the vineyard, emphasizing the high influence of local ecosystems on the way ES are provided to the wine-grape production. The interactions between the different viticulture practices and the ES in the review are all represented with thin purple arrows. They only symbolize the existence of an interaction, without taking into account the positive or negative influence of the practice on the targeted ES. Both the ES and the interactions arrows' size are adjusted to the number of quotes counted in the literature, in order to differentiate the most studied topics from the ones more rarely tackled. This diagram shows obvious concentration of the literature on some ES in interaction with specific viticultural practices. Potential reasons of this concentration of information will be discussed in the following paragraphs proposing further reflection on the corpus of this review.

V.3 Approaches of the articles and impact on viticulture practices

Studies showed different approaches and emphasis according to the context and the scale they were led in: the focus of the studies varies from ES to the ecological process underlying them, or from the ES provided to the ES generated by the vineyards.

V.3.1. THE EMPIRICAL EVIDENCE APPROACH

Many scientific studies choose to tackle the subject of ES and viticultural practices through classical academic methods: these articles aim at better describing the ecological processes sustaining the ES on vineyards in order to quantify the benefits they bring to the viticulture activity and / or to measure the impact of viticulture practices on their happening. They are mostly led at the plot and field to landscape scales, focusing on the ecological processes driving one or a few ES provided to the vineyard, in interaction with a set of precise practices. Following research methods are the base of the studies showing an academic approach:

- Biodiversity measurement are used at diverse scales to study the different manifestations of biocontrol ES: some measure insects functional biodiversity at plot and field scales, focusing on natural enemies of vines' pests (Caprio et al., 2015; Rochard, 2014); while others look at the functional micro-biodiversity in the soil involved in the plant health management (Danne et al., 2010; Salomé et al., 2015;

Trouvelot et al., 2015; Whitelaw-Weckert et al., 2007). Jedlicka et al., (2011) focuses on the birds biodiversity, showing the active role of insectivorous birds in pests control.

- The soil fertility and generation ES constitute another focus point. They are described by soil microbial activity, soil micro-biodiversity and soil nutrients' content measurements. They are often studied in interaction with key soil management practices, such as soil labour and cover-crops (Castañeda et al., 2015; Danne et al., 2010; Salomé et al., 2015; Whitelaw-Weckert et al., 2007).
- Finally, some researchers adopt the economical approach to value some of the key ES, calculating the money saved by viticulturists when they use methods to enhance ES rather than using synthetic inputs with higher monetary costs. For example, Sandhu et al. (2016) published a study showing that the application of mulch under-vines during the winter-time disturbed the development cycle of Botrytis cinerea fungus and reduced its pressure up to 70%, thus enabling Australian vine-growers to save 570$ per ha linked to fungicides' application.

These studies can serve as a base for scientists to defend the benefits of enhanced ES on vineyards in front of the wine-sector stakeholders. Nevertheless, the risk of the academic approach lies in the lack of occasions, formation or interest for transmitting the findings to the viticulturists.

V.3.2. THE "ENVIRONMENTAL IMPACT" APPROACH

Some studies adopt a more holistic approach of the vineyards, looking the resources used, transformed and produced by the viticultural activity. Their goal is to enhance the optimization of natural resources use for viticulture, or the minimization of environmental impact of the viticultural practices. Among the selected articles, following tools seem of particular interest:

- Modelling enables to represent the evolution of resource availability over the coming years and the implication it has for the wine sector. Two studies used this method in Chile (Hannah et al., 2013) and South-Africa (Elsawah et al., 2015): Hannah et al. (2013) confronted 17 different Global climate models (GCMs) applied to suitability for grape growing to Chile to draw conclusions about the current and upcoming challenges to ensure water availability for vine-growing activity; Elsawah et al use (2015) participative modelling method to better understand the water management strategies of South-African viticulturists.
- Villanueva-Rey et al., 2014 adopts the life cycle analysis methodology to compare the environmental impacts of different conventional and biodynamic management

paradigms. They underline that the consumption of fossil fuels for tractors is a key factor of global energy consumption and environmental impact of viticulture.

- Danne et al. (2010) and Tompkins, (2010) emphasize native wild biodiversity as a resource for Australasian vineyards. They underline the high potential of vineyards to become refuges of native wild biodiversity around the vines plots through native ecosystems conservation and within the plots through native cover crops integration. Brunori et al., (2016) and Salomé et al. (2015) present the vineyard's soil as a key resource to provide climate regulation services through carbon sequestration.

The use of models to represent the potential evolution of the resources under the influence of viticulture activities, in particular for the native biodiversity, can be an interesting tool to generate awareness among the stakeholders of the wine-making world.

V.3.3. THE EDUCATIONAL APPROACH THROUGH SUSTAINABLE VITICULTURE INITIATIVES

ES for vineyards are also used in the context of the sustainable wine growing projects. They are designed by and for the viticulturists themselves in tight cooperation with academicians or / and policy makers. The International Organisation of Vine and Wine (OIV) and the International Federation of Wines and Spirits both published guidelines and codes for sustainability of the wine sector. They were considered as a basis for the development of local (within a wine-making valley), regional or national scale programs. In this context, ES are mentioned as key support for the sustainability of wine-making activity, defined as "the ability to economically provide for the viticulturist while maintaining its ability to consistently produce and improve quality over time" (Santiago-Brown et al., 2014a). The methodologies used for such projects have a highly participative and educational purpose:

- Many of the sustainable viticulture projects start with a self-assessment of the viticulturists. They use sustainability indicators covering all the viticultural practices and their environmental impact, economic and human labour costs and emphasizing the enhancement of a diversity of ES. Self-assessment enables viticulturists to acquire a clear view of the strong and weak points of their management strategy, and to deduce the changes they can operate to better integrate ES in their vineyard management (Lamastra et al., 2010; Ohmart and others, 2008).
- Workbooks proposing concrete steps to implement sustainable practices on the vineyards were developed in California (Ohmart and others, 2008), South Africa ("Biodiversity & Wine Initiative," 2016), Chile (Wines of Chile, 2008) Oregon ("LIVE: Supporting environmentally and socially responsible winegrowing in the Pacific

Northwest," 2016). In Chile, the WCCB team developed a workbook targeted on biodiversity conservation practices (Barbosa and Godoy, 2014).

- Most of the sustainability programs developed certification systems, enabling vineyards to value their efforts with marketing arguments, while defining a set of conditions for vineyards to be considered as sustainable (Santiago-Brown et al., 2014b).

Overall, the sustainable viticulture initiatives worldwide are major drivers of the enhancement of ES in the viticulture activity. They enable to include less valued services such as cultural ES in viticulturists' valuation of ES (Ohmart and others, 2008; Santiago-Brown et al., 2014b; Tompkins et al., 2012). However, the international team of researchers linked to the WCCB temper the efficiency of the sustainability projects at the landscape scale as greater attention is put on the practices reducing the environmental impact of viticulture than on the vineyards' landscapes sustainability. They recall the importance of concrete biodiversity conservation actions as the base of a sustainable balance at landscape scale (Webb et al., 2011).

V.4 ES and management paradigm

One of the objectives of this study is to determine if the management paradigm applied to a vineyard influences the way ES are considered and integrated in the viticulture practices. Internationally, a clear difference is made between organic, conventional and biodynamic management paradigms, regulated at national to continental level by laws and certification. The prohibition of use of synthetic inputs for fertilization, weeds and pests and diseases management in organic vineyards is a common point worldwide (Caprio et al., 2015; Morganstern, 2008; Reeve et al., 2005). The biodynamic management encompasses a more holistic approach, based on the minimization of the use of external inputs from outside the vineyards to meet production goals (Reeve et al., 2005). Between these categories, the terms sustainable and integrated viticulture are also commonly used to qualify viticultural practices. These paradigms are less regulated than the previous, depending on local initiatives from the authorities or within the wine sector. Overall, a high diversity of practices and strategies can be observed among all categories, depending on how viticulturists themselves perceive their vineyards agroecosystem. Two main trends seem to drive the perception viticulturists have about their vineyard's agroecosystems, may their management choices be organic or conventional:

- Some consider the vineyard as a production unit, with controlled and calculated inputs and outputs. In this framework, practices are chosen in order to ensure human control on the ecological processes leading to plants' nutrition and health management. Organic viticulture can be applied in this context, by substituting the

synthetic and mineral inputs by organic and biological control inputs (Caprio et al., 2015; Villanueva-Rey et al., 2014).

- Vineyards can also be considered as “living organisms”, in which ecological processes play an essential role in vine’s nutrition and protection. In this context, viticultural practices aim at creating and maintaining a sustainable equilibrium while reaching production objectives. The provision of precise nutrient’s doses and the direct intervention for plant health management comes thus as a complement to natural occurring of these phenomenon (Pino Torres, 2013; Reeve et al., 2005). Most of the studies reporting this vineyard’s perception are based on organic or biodynamic managed vineyards, nevertheless this logic is also partially applied in some vineyards with “integrated management”.

On the one hand implementation of concrete practices to integrate and enhance ES while meeting the production goals of a vineyards remains a delicate topic, as ecological processes and the resulting services are highly depending on the local edaphic and climatic conditions. Moreover, many of the processes leading to key ES are still partially known and therefore their interaction with viticulture practices are still uncertain and fuzzy (Salomé et al., 2015). On the other hand, the distinction between the different management paradigms needs to follow precise criteria enabling the elaboration of laws and rules for certifications and international trade. As a consequence, most of the papers and laws differentiate the organic from conventional viticulture on the base of the fertilization practices and the use of synthetic products for weeds, pests and diseases managements (Brunori et al., 2016; Caprio et al., 2015; Reeve et al., 2005; Villanueva-Rey et al., 2014), while defining integrated practices as a mix of organic and conventional practices chosen by the vine-growers (Ohmart and others, 2008). Nevertheless, this review emphasized how the provision of ES on the vineyards depended on many other factors in addition to those taken as a reference to distinguish the different management paradigms. Therefore, the integration of ES in vineyards doesn’t seem to depend on the choice of a given management paradigm, but rather depends on the vision that viticulturists have of their vineyards in their local context and the knowledge they have on local ecological processes (Winkler and Nicholas, 2016). Under these conditions, organic producers with the “producing unit” perception of their vineyard may not value the ES as much as integrated or conventional producers with “living organism perception” of their vineyards.

Increased integration of Ecosystem Services in the practices →

Objective of human interventions	ES replacing practices	Mixed practices	ES based practices
Yield and canopy management	Manual / involves machinery	Manual / involves machinery	Manual, use fertilization, irrigation and cover crops strategies to regulate vigor
Fertilization	mineral inputs	mineral and organic inputs	soil life enhancement through organic inputs and biodynamic preparations
Interrows soil cover	Bare soil	annual cover crop cleared in summertime (to avoid competition for water)	permanent cover crops or natural grass regularly mowed, special cover crops mixes linked to canopy and fertilization management
Interrows soil labour	ploughing	superficial soil work, decompaction	Decompaction according to needs
Undervine / weed management	Bare soil maintained with herbicide application	bare soil maintained with mechanical work and herbicide application	permanent cover crops and / or mechanical weeding
Pests and diseases management	use of synthetic pesticides and fungicides, sulphur and copper	sulphur, use of synthetic pesticides and fungicides, sulphur and copper / induced biocontrol	sulphur and copper, induced and / or conservation biocontrol
Irrigation	Drip irrigation	Drip irrigation	Drip irrigation, management of the soil and the surroundings to create sufficient humidity and water retention, selection of varieties adapted to local climate
Landscape elements management	Exotic and native species around the vineyard, no direct use in the vineyard	Exotic and native species, may be used as ecological corridors, possible presence of flowering strips to attract natural enemies	Native and exotic species, used within and around the vineyards as melliferous flowering strips, biocontrol bushes and ecological corridors; Crop diversification to provide the plants and animal products necessary for the biodynamic preparations
Cattle on vineyards	Present / absent , no production use	Present, may be used for fertilization / absent	present, used for pests and diseases and fertilization management and biodynamic preparations
Harvest	mechanical / manual	Mechanical / manual	mechanical / manual

Table 2. (to be considered in the next page text) Different degrees of integration of ecological processes by viticulture practices.

V.5 Conclusions

V.5.1. ENHANCE ENTERING ES TO PROVIDE ES

This review of the ES studies applied to the wine-making world showed diverse and complementary approaches. The studies make evidence of the key role played by natural ecological processes in the sufficient production of grape of good quality, while showing their high sensitivity to viticulture practices. It is noticeable that vineyards are croplands with high potential of receiving and providing ecosystems services (Tompkins et al., 2012), nevertheless the ability of vineyards landscapes to provide ES highly depends on the way they integrate the ES they receive (Viers et al., 2013). Indeed, the better the entering services are integrated in the vineyard management, the highest is the potential of the vineyard to provide ecosystem services at landscape scale (Altieri and Nicholls, 2002; Brunori et al., 2016; Caprio et al., 2015; Salomé et al., 2015; Tompkins et al., 2012). In other words, "the more similar a [vineyard] looks to the biogeographic region's natural ecosystem, in terms of structure and function, the greater is the probability for this Agroecosystem to be sustainable" (Altieri, 2014, p. 37).

V.5.2. VITICULTURE PRACTICES: ENHANCING OR REPLACING ES?

This review enabled to list numerous interactions between viticulture practices and ES. While some practices were identified as beneficial for the ecological processes driving the provision of ES, others were underlined as slowing or at least modifying the way ecological processes occur in a way that the provision of ES is slowed or replaced by human intervention. Table 2 (see front page) presents a summary of all the practices reviewed in the detailed literature review, classified according to their variable integration of ecological processes and the ES they support. The application of a management paradigm oriented towards sustainability, such as organic, biodynamic or some integrated vineyards, may orient their management towards the ecosystem based practices mentioned in the table. Nevertheless, current differentiation of these different paradigms focus on the mere use of synthetic inputs for fertilization, pest, diseases and weed management, leaving fuzzy criteria about other practices with a key effect on the provision of ES such as the soil labour and cover management or the landscape elements management.

V.5.3. SUSTAINABILITY AND ES

Under combined influence of the international wine organizations, the threats linked to climate change and the opening of new market opportunities for organic wines, the wine-sector has been getting more sensitive to the concept of sustainability (Hannah et al., 2013; Viers et al., 2013). Growing numbers of sustainable wine-making projects at local, regional and national scales participate to the progressive understanding and valuation of the ES by viticulturists through the development of locally adapted self-assessments methods and

educational programs (Santiago-Brown et al., 2014b; Webb et al., 2011). These programs enabled to consistently reduce the environmental impact of the participant vineyards and opened their perception of the vineyards' agroecosystem to the landscape scale, progressively integrating the non-cropped areas as part of their management (Ohmart and others, 2008).

However, efforts are still needed to better integrate the conservation of native wild biodiversity within and around the vineyards, in a balanced proportion of surfaces at the landscape scale (Webb et al., 2011). The actual transition of viticultural practices to seek for more sustainability often happens at regional level, boosted by an active network of concerned wine-makers where the leaders of the movement play a key role in developing and transferring local knowledge and innovations (Ohmart and others, 2008; Santiago-Brown et al., 2014b)

Chilean viticulture, and in particular the WCCB partner vineyards, is characterized by large properties where the surface of vineyards is similar to minor in comparison with the non-planted area. Therefore, most of the vineyards present a high potential for native biodiversity conservation. The review showed the importance of the presence of biodiversity within and around the vineyards, may it be spontaneous or planned, for the enhancement of key ES. Focused on the valuation of the ES through the native biodiversity, the WCCB approach is an at the crossroad between the academic and the sustainability projects (through the pedagogic activities) approaches.

VI. RESULTS STEP 2: DEFINITION AND INTEGRATION OF ES IN THE WCCB PARTNER'S VINEYARDS MANAGEMENT

VI.1Introduction

The second step of this thesis work consists in exploring the ES concept with some of the WCCB partner vineyards' staff. The literature review enabled to get an overview on the different ways the ES concept is being approached all over the world. It is noticeable that most of the methods to assess Ecosystem Services are being focused on the development of biophysical indicators, at the cost of the analysis of social demand for ES (Turner et al., 2016). Likewise, conservation studies are most often carried out by natural sciences experts, privileging a quantitative approach to generate interest and influence conservation decisions (Newing, 2010). The development of research projects in cooperation with concerned stakeholders is not very favoured yet by many scientists, regarding the slower pace imposed to research progress by the construction of the relationship and the common understanding with the non-academic partners. Nonetheless, several works underlined the positive consequences of the integration of stakeholders as co-designers of the research protocol on

the application of the results and the increase of awareness afterwards. For example, Pain et al. (2016) managed to mobilize the majority of the viticulturists of a French appellation sector for the plantation of 20 km of linear hedges forming ecological corridors and stepping stones from spontaneous biodiversity within and between vineyards. They noticed a concrete change in viticulturists' involvement in their project when they started to include the viticulturists in the co-design of the project. The participation of the viticulture managers of the WCCB partner vineyards was considered as central for this exploratory study. This study aims at giving some orientation tools to the WCCB team, in order to increase the impact of the program on the partners' involvement for native biodiversity conservation. It also ceases the occasion of questioning the reliability of the concept of management paradigm, defined as the way viticulturists qualify their production methods, to illustrate a certain level of awareness of the ES concept and of its application to viticulture. Indeed, it is common to think that organic, biodynamic or integrated management paradigm lead to increased awareness of the participation of natural ecological processes in the viticultural activity. Hence, the following paragraphs present the results of the analysis of the 21 semi-structures interviews led with the vine-growers of nine of the partner vineyards. Figure 18 presents the population of interviewees, emphasizing the hierarchical links between the staffs of the same vineyard, and the potential influence of previous experiences in other vineyards represented in the population:

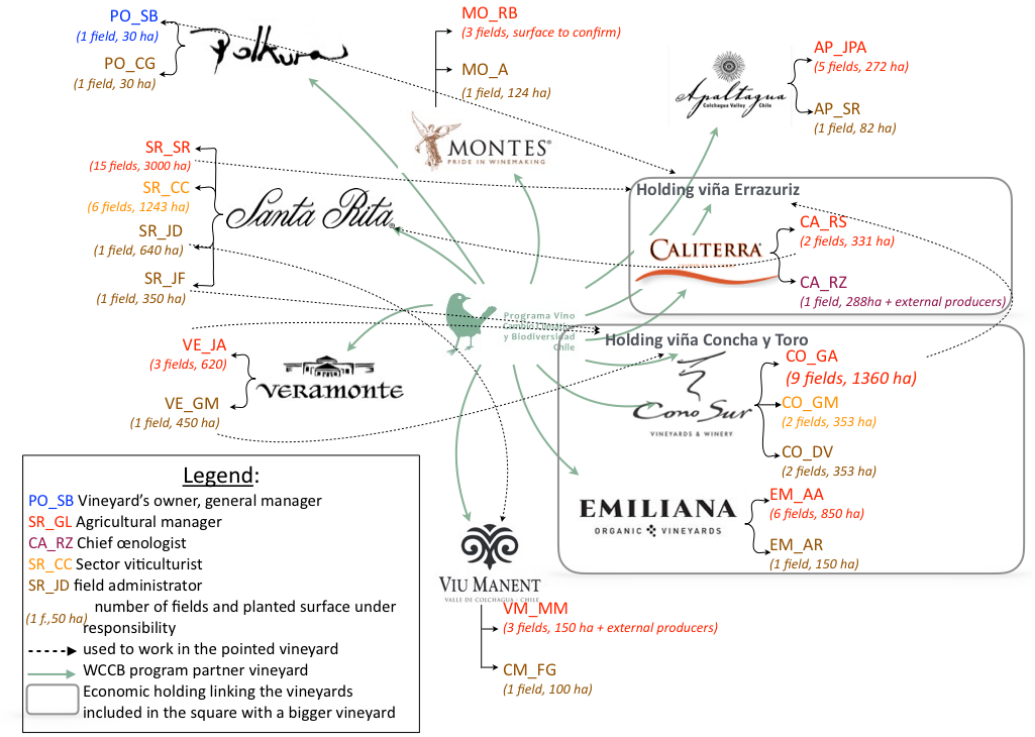


Figure 18: *Graph showing the 21 interviewees linked to the vineyard they are working for. Hierarchical positions are detailed with the colours, links between the vineyards through economic alliance are presented in the grey squares and previous experiences of some of*

the viticulturists interviewed in one of the visited vineyard are represented with doted arrows.

Regarding the tight links between the interviewees, no statistical analysis could be made to test the hypothesis. Therefore, all the analysis led in this study will be qualitative, and the conclusions will remain propositions to further confirm the hypothesis. In a first time, the different management paradigms of the visited vineyards will be presented using the definition of the viticulturists. In a second part, a synthesis of the information gathered about the viticultural practices will be presented, discussing the potential drivers of the decisions of the viticulturists for each specific practice. Then, viticulturists' understanding of the ES concept and its application to their vineyards' context will be presented and synthetized into a second diagram realized on the same basis than the conceptual diagram presented in the literature review.

VI.2The management paradigms described by the viticulturists

VI.2.1. MANAGEMENT PARADIGMS: A STATE OF MIND

The viticulturists all explicitly defined their ways of growing vines, resulting in the five distinct management paradigms presented in table 3:

Management paradigm	**Number of viticulturists**	**Number of vineyards**
Conventionnal	3	1
integrated	11	5
Integrated_organic	3	1
Organic_transition	2	1
Biodynamic	2	1
Total	**21**	**9**

Table 3. Presentation of the different management paradigms defined during the interviews

Some vineyards present both integrated, conventional and / or organic management. As a consequence, some viticulturists are asked to manage plots with different paradigms within the same property, while the managers of different fields in a same vineyard are often managing different management paradigms across their fields.

The viticulturists gave different justification for their management paradigm:

- The integrated viticulturists with long experience in vineyards seemed to differentiate the integrated management from the conventional by comparison to their former practices: they mentioned the transition between the period of systematic use of chemical inputs for pests and diseases management to the current management based on monitoring and localized applications. Others mentioned the reduction of the chemical products use to a list of products certified for compliance to exportation to European countries and / or sustainability certifications.
- The managers of the vineyard in organic transition, and the viticulturists managing both organic and integrated and the biodynamic vineyards mentioned the transition to organic or biodynamic management as a “change of chip”. They referred in particular to the completely different approaches of the vines’ phytosanitary protection, where the enhancement of biodiversity on the vineyard gets a key strategy to prevent the spreading of pests and diseases, while the curative strategies are based on regular monitoring, using organic certified products. They also mention the drastic change of fertilization strategies, based on the biological processes rather than on the calculation of a precise number of nutrients’ units to provide according to the production goals. All of them defined organic fertilization as the enhancement of soil life to stimulate organic matter decomposition and the natural liberation of available nutrients for plants.

The biodynamic vineyard managers add a dimension of energetic flows to their management. their activity include the cropping of special species used in the preparation of biodynamic preparations applied at precise moments of the vines’ cycle but also integrated in the fertilization and pests and diseases management strategies.

VI.2.2. THE ROLE OF CERTIFICATIONS

All the vineyards considered in this study counted on more than one certification concerning the vine-growing activity. Following certification types were identified and described by viticulturists:

- Exportation certifications, namely Global Gap and ISO, testify the compliance to international hygiene norms and ensure traceability all along the wine-making process.
- Sustainability certifications, at national (sustainability code of Wines of Chile, governmental “Acuerdos de Producción Limpia”) and international levels (B-corp, Neutral-C, Fair for Life) emphasize in different modes the evolution of the vineyards towards more sustainability, some through the adoption of “good environmental

practices", other through the development of social projects and the improvement of working conditions and wages for the vineyards' staff.

- Organic certifications are delivered by the Swiss IMO and the German BCS certification organisms, while biodynamic certification is delivered by the German Demeter label.

The viticulturists expressed varied opinions about certification: while some recognized to have achieved actual changes in the organization of their work and in some viticultural practices, others consider it more as a time consuming administrative constraint necessary to comply with marketing and export conditions. The viticulturists didn't identify the certifications as a source of awareness about the natural ecosystems and their participation to the productive process. They paradoxically most often referred to certifications' lists of authorized and prohibited chemical products for fertilization and pests and diseases management as a reference when choosing their strategies for pests, diseases and weeds management every year. Some even mentioned the colour code established in the sustainability code of Wines of Chile to value the environmental impact of the phytosanitary products as a reference to illustrate their involvement in sustainable management of their vineyard.

VI.3Viticultural practices of the WCCB partner vineyards

The detailed description of the viticulture practices applied on the visited vineyards is available in appendix V. The results of this work are synthetized in table 4 (see back page). While analysing the information, particular attention was paid to how the viticulturists argued their choices of applying each practice they presented. Different potential drivers of choice were thus identified, leading to following reflections:

- The management paradigm seems to exert a varying influence on the different practices. While being determinant for the fertilization and the weed management practices, it doesn't condition the inter-rows management. The pests and diseases management is partially influenced by the management paradigm, although common points, such as the preventive applications of sulphur on the whole vineyards, could be observed among all the participant vineyards in spite of their sometimes opposed management paradigm.

Practices	*Drivers of choice*	conventional	Integrated, sustainable	organic, biodynamic
Yield and canopy management	*Yield and quality objectives* *Financial means*	Minimal intervention: manual winter pruning, integration of pruning residues, mechanical green pruning if needed	manual winter pruning, integration of pruning residues, use of irrigation and cover crops strategies to regulate vigor; Biodynamic preparations complementary pruning and leaf-plocking in spring according to quality	
Fertilization	*Management paradigm* *Yield and quality objectives*	100% mineral: Liquid or solid mineral inputs	mineral and organic inputs in different proportions: mineral comes as the base or the complement to organic fertilization.	soil life enhancement through applications of composts, organic inputs and / or biodynamic self-made preparations; regular soil analysis.
Interrows soil cover	*Soil characteristics* *Water availability* *Personal knowledge about vegetal cover uses*	permanent or partial cover crops or natural grass regularly mowed; annual cover crops or natural pasture partially cleared in summertime (to avoid competition for water) Special cover crops mixes linked to vigour control and fertilization management		
Interrows soil labour	*Soil characteristics* *Machinery use* *weed management*	No-tillage / superficial soil work / ploughing decompaction according to needs		No-tillage, superficial soil work decompaction according to needs
Undervine / weed management	*Management paradigm* *Yield and quality objectives*	Bare soil maintained with mechanical work and / or herbicide application winter weeding with sheep or cattle		Bare soil maintained with mechanical weeding winter weeding with animals
Pests and diseases management	*Financial means* *Personal knowledge* *Management paradigm for the type of products applied*	Monitoring of pests and natural enemies, Use of synthetic pesticides and fungicides, sulphur induced and conservation biocontrol		Monitoring of pests and natural enemies, Use of sulphur, induced and conservation biocontrol and organic pesticides and fungicides
Irrigation	*Soil characteristics* *Yield objectives* *Water property rights*	Drip irrigation, management of the soil and the surroundings to create sufficient humidity and water retention.		
Landscape elements management	*Vineyards' landscape structure, personal interest ecological knowledge*	Exotic and native species, depending on the vineyards' initial landscape Natural or designed ecological corridors may be used to attract natural enemies		**Only biodynamic** : crop diversification to provide the plants and animal products necessary for the biodynamic preparations
Cattle management	*Ecosystems' degradation state* *Fire risks* *Ecological knowledge*	Absent (prohibited) or present within (winter weeding) and around the vineyards		present, used for pests and diseases and fertilization management
Harvest	*Wine-making equipment,* *wine quality*	mechanical and manual		

Table 4. Table of the practices of WCCB partners vineyards and their main drivers, linked to their management paradigms

- Some practices seem to vary according to the personal knowledge of the viticulturists: for example, a variety of uses and opinions about the use of cover-crops was identified. Likewise, the management of non-cropped species between the vine plots and around the vineyards varied greatly according to the viticulturists' ecological knowledge and interest: independently from the presence of large or reduced natural areas surrounding their vineyards, some viticulturists barely mentioned the landscape elements as part of their management strategies while others presented it as part of their management priorities. Finally, the strategy of management of animals within and around the vineyards seems to depend on the awareness of the viticulturists on the ecological processes leading the degradation of natural ecosystems and the resulting risks of fires during the dry season.
- The management of the soil and the irrigation strategies were highly influenced by the special characteristics of the vineyards' soils.

The objectives of quality and yields, fixed by other staffs of the firms (from the sales and oenological departments), are determinant factors of the financial means on which the viticulturists dispose to apply their management, hence conditioning their ability to realize human intensive labours such as the yield and canopy works; as well as the type of inputs they buy for pests, diseases and weed control and fertilization.

VI.4Ecosystem Services identification

VI.4.1. ECOSYSTEM SERVICES DEFINITION

One of the first steps of the interview consisted in agreeing in a definition of the ES concept. Thirteen out of the twenty-one interviewees affirmed to be hearing the term "Ecosystem Services" for the first time. In both cases, the viticulturists were asked to define the concept with their own words, before suggesting the orientation of the ES definition chosen for this study. The definitions proposed by the interviewees varied greatly. As shown in figure 19, only one person felt unable to find a sense in the terms, while the others expressed their own thought about the topic:

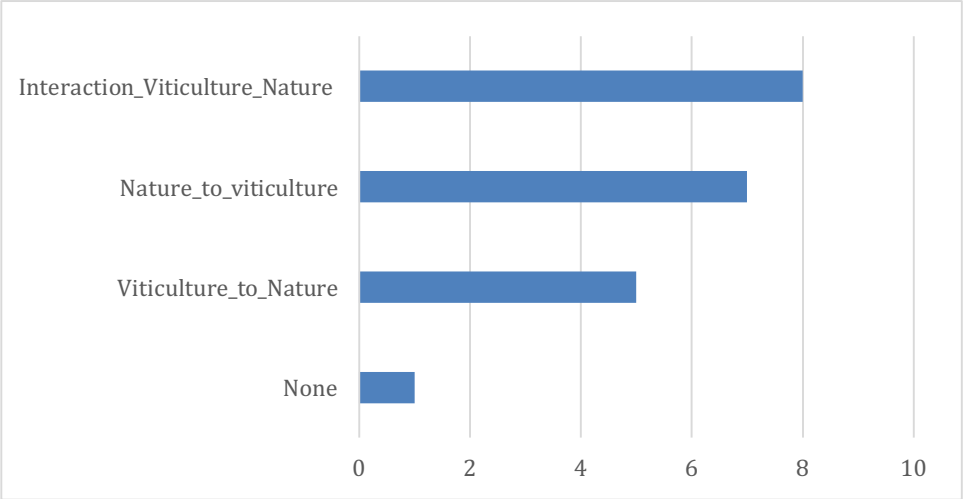


Figure 19: *Personal definitions of the Ecosystem Service concept: numbers of viticulturists in each group.*

Three main groups of personal definition can be distinguished:

- Some viticulturists define ES as benefits from natural ecosystems to the vineyards agroecosystems. They link the ES to the presence of native vegetation and native fauna, recognizing that they "get helped from the natural ES, from nature for all the production steps" (CA_RZ). Their approach is close to the one of the WCCB team.
- Other viticulturists define the concept as the result of their environmental initiatives within the vineyard on the surrounding natural ecosystems, such as the limitation of herbicide use on the mere vine-rows. They also make a clear distinction between vineyards agroecosystem and natural ecosystems. For them, an "Ecosystem Service" is a service they lend to the natural ecosystem by "being less toxic in [their] viticultural management" (SR_CC).
- Finally, the last group of viticulturists define the concept of ES as an interaction between the vineyard agroecosystem and the surrounding ecosystems. They consider their activity as a work "hand in hand with Nature" (AP_JPA), defining the ES as the result of the interaction between the vineyard and the surrounding ecosystems. They underline the importance of creating a balance within the vineyards' agroecosystem by enhancing (or restoring) a diversity of species in both the flora and fauna.

After understanding the position of each viticulturist on the subject, an agreement on a common definition was made, putting the emphasis on the participation of natural processes in the viticulture activity.

VI.4.2. ES IDENTIFICATION: DIVERSE LEVELS OF AWARENESS

The identification of the different ES identified by the viticulturists was based on the classification established during the literature review. Hence, during the analysis of the interview transcripts, the reference to some key ecological processes or the use of key words (like “natural enemies” for biocontrol, or “living soil” for soil Fertility) were associated with the corresponding ES. Particular attention was paid during the interview to how the viticulturists recognized the different ES. Indeed, after having defined the concept, some were able to give concrete example of ES occurring in their vineyard, while others still struggle to identify concrete application of the concept to their reality. After that, all the interviewees referred to some ES while speaking about their viticulture practices, either making a direct link between the service and the previously defined concept or establishing an indirect link with the natural ecosystem. Following the example of other social valuation studies, the ES which were identified without making a direct link with the concept defined at the beginning of the interview were registered as “indirectly identified” (Cáceres et al., 2015). The direct recognition of some ES confirms the awareness of the viticulturist about the ES, while the indirect recognition demonstrates that viticulturists may be using the ES without being aware of them. Figure 20 shows the proportion of direct and indirect identification of each ES:

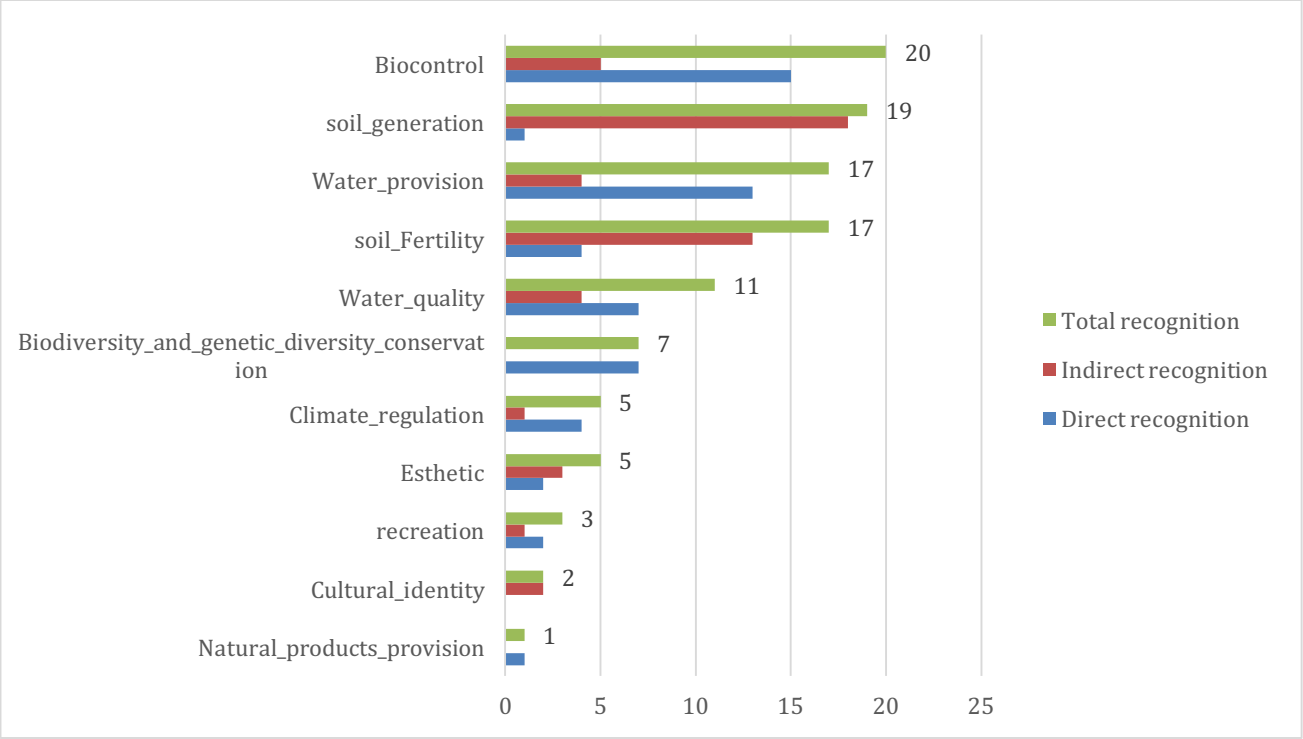


Figure 20: *Classification of the ES according of the number of viticulturists who recognized them*

The four most valued ES, identified by more than fifteen of the twenty-one viticulturists, were Biocontrol, the Soil Generation, soil Fertility and water provision. The ES related to the soil, seeming more intangible and invisible, were mostly indirectly acknowledged, while the more eye-observable biocontrol and water provision ES were more spontaneously named.

Among the other ES, the water quality was identified by half of the interviewees, and the third of the viticulturists recognized the importance of Biodiversity and genetic patrimony conservation. The cultural ES were mentioned by few people, mostly indirectly and only one viticulturist recognized the possibility to value the natural products of the native vegetation.

VI.4.3. INTERACTIONS BETWEEN ES AND VITICULTURE PRACTICES: THE VITICULTURISTS' VIEWS

The interactions between viticulture practices and ES mentioned by the viticulturists during the interviews were listed and counted and summed. The detailed description of each interaction is available in appendix VI. Figure 21 (see back page) shows the final diagram resulting from the coding and analysis of the interviews. The most quoted interaction was the influence of non-cropped species on the presence of natural enemies on the vineyards. The soil cover and labour strategies applied in the inter-rows were also often linked to a bundle of ES. In particular, many viticulturists expressed their astonishment regarding the efficiency of vegetal soil covers in maintaining and even improving the soil fertility and structure in comparison to bare soil inter-rows.

The red arrows represent interactions that were mentioned by the viticulturists whithout being identified in the literature review. They mostly concern the integration of animals in the vineyard's management and the integration of the pruning residues to structure the soil of the inter-rows, common practices in the Chilean context that were not mentioned in the literature.

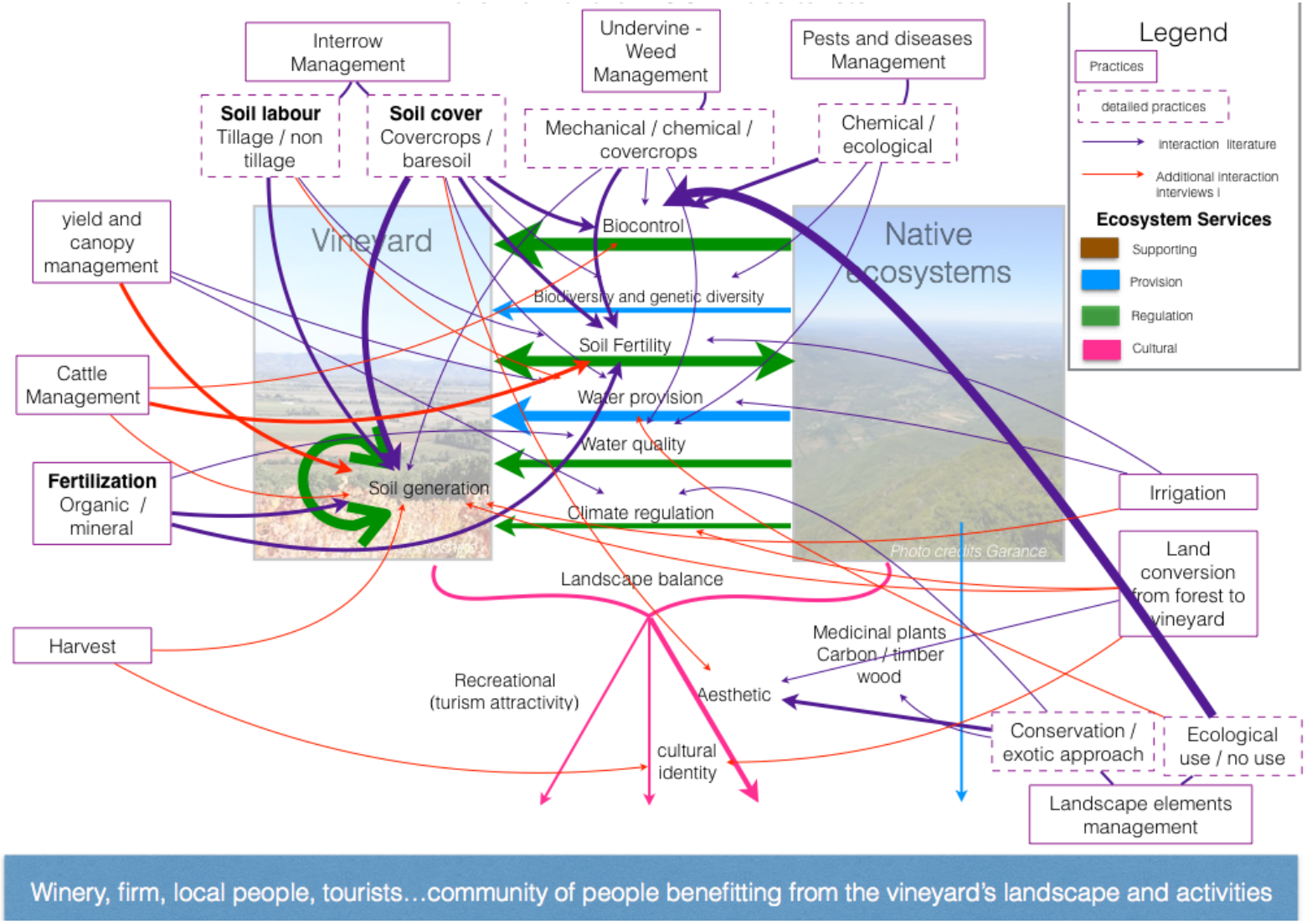
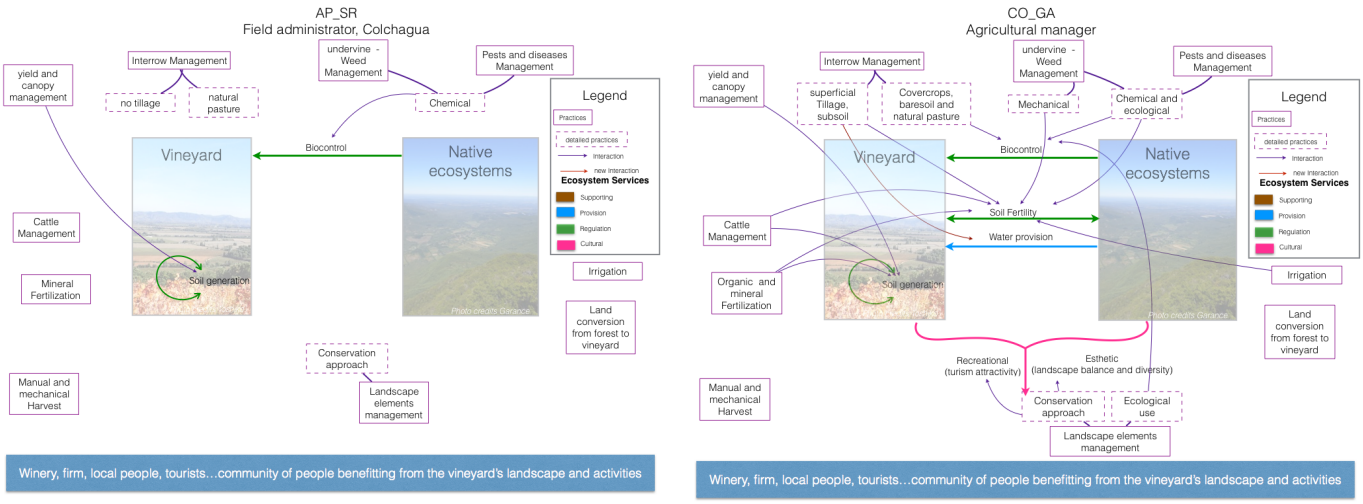


Figure 21: *Interactions between ES and viticulture practices: the view of WCCB partner viticulturist*

VI.5 Variations in the individual perceptions of viticulturists: is the management paradigm a potential factor of awareness?

Each of the interviewed viticulturist expressed a very different perception of the ES and their application to his activity, illustrated by the examples of two viticulturists' personal diagrams in figure 22:



(a) (b)

Figure 22: *Examples of viticulturists' diagrams of ES and interactions with their practices: (a) conventional field administrator, Colchagua valley; (b) agricultural manager of integrated and organic vineyards. this comparison shows the variability of the ES and the interactions identified among individuals*

One of the hypothesis of this study was that the management paradigm applied by the viticulturist had an influence on their perception of the ES in interaction with their viticulture practices. Therefore, the variability of the answers will be qualitatively analysed in the following paragraphs.

VI.5.1. ES DEFINITION AND IDENTIFICATION

Table 5 (see back page) shows the individual variations among the viticulturists in their intuitive definition of ES concept according to their management paradigm. Out of the 21 interviewees, the only viticulturist who could not give any intuitive definition of the concept was leading his vineyard under conventional principles. 4 of the 5 viticulturists who considered that ES concept referred to services from viticulture towards natural ecosystems had integrated management and the fifth was in organic transition. All the other viticulturists considered the ES concept as an interaction between the vineyard agroecosystem and the surrounding natural ecosystems or as services that their vineyards' agroecosystems were receiving from the natural ecosystems.

ES concept definition	None	Viticulture to Nature	Nature to viticulture	Interaction Viticulture – Nature	**Total**
Biodynamic			1	1	**2**
Organic transition		1		1	**2**
Integrated and organic			1	2	**3**
Integrated		4	5	2	**11**
Conventionnal	1			2	**3**
Total	**1**	**5**	**7**	**8**	**21**

Table 5. Repartition of the viticulturists according to their management paradigm and their intuitive definition of the ES concept

Figure 23 shows the variations of the number of ES identified by the viticulturists according to their management paradigm:

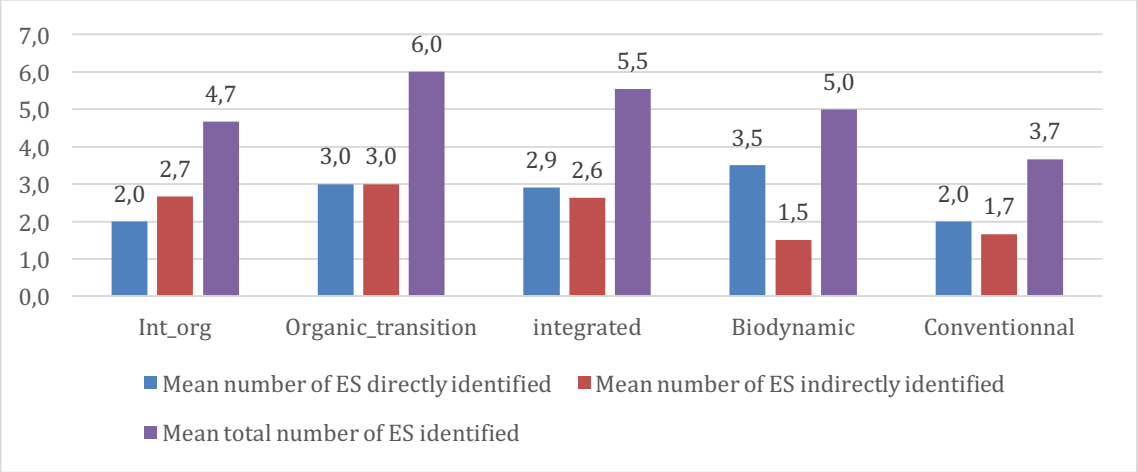


Figure 23: *Comparison of the mean numbers of ES directly, indirectly identified, the total ES identification by the viticulturists according to their vineyard's management paradigm*

The overall identification of ES and of their interactions with viticulture practices resulted in different rankings of the management paradigms. The total ES identification led to following ranking:

1. Organic transition.
2. Integrated management
3. Biodynamic management
4. Integrated and organic management
5. Conventional management

These results seem to confirm the hypothesis that conventional viticulturists identify less ES than the viticulturists showing an environmental awareness in their practices.

Surprisingly, the viticulturists applying Biodynamic management recognized less ES than the one recently converted to organic viticulture and the integrated viticulturists. It is interesting to notice though that the biodynamic viticulturists named most of the ES spontaneously, while the viticulturists with other management paradigms had similar rates for direct and indirect identification, with indirect sometimes even dominating over direct identification (for the integrated management paradigm).

Figure 24 shows the mean number of interactions identified by the viticulturists between their viticultural practices and the ES they identified according to their management paradigm:

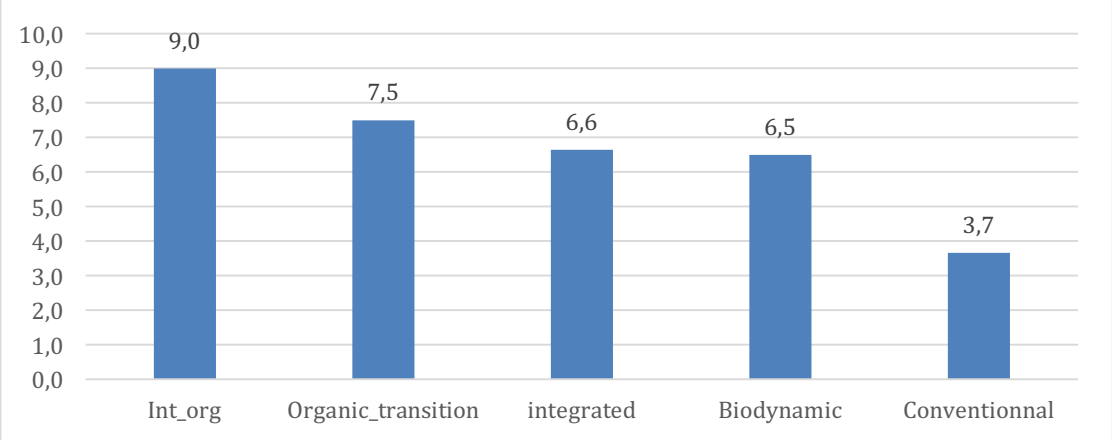


Figure 24: *Comparison of the mean number of interactions between ES and viticulture practices mentioned by the viticulturists according to their management paradigm*

The structure of the hypothesis is also partially respected in this result: the conventional viticulturists identified the least interactions, while the other viticulturists show similar awareness of the interactions of their practices with the ES. The viticulturists leading two different management paradigm seem to perceive more interactions than the other. It may be explained by the differences they can observe on their fields when taking different decisions in front of the same issues. These contradictory results are in agreement with another study led with New-Zealander arable farmers, where conventional farmers were found to identify and value as many ES as organic farmers, expressing equal will to better integrate them in their farm management but lacking knowledge and (Sandhu et al., 2007). Besides, Winkler and Nicholas noted an influence of what they call the “farming style” on wine-makers perception of cultural ES, saying that producers more oriented towards productivity don't value as many CES as producers encompassing an environmental stewardship. This is in coherence with the low scores of the conventional viticulturists, who expressed clear priority of the yield over quality objectives.

VI.5.2. OTHER POSSIBLE FACTORS OF VARIATION OF VITICULTURISTS' KNOWLEDGE

Many other criteria could have been looked at as a complement to try and explain the variability of awareness about the ES and their interactions with viticulture practices, however the time limited the analysis to this hypothesis. If no study assessing viticulturists' perception of ES was found, some studies are being published about stakeholders' perception of ES in other contexts. For example, Zhang et al. (2016) noticed an increased awareness of ES under the influence of exposure to forest and unused land in African villages. It would thus be interesting to assess the influence of the proportion of non-planted area managed by the WCCB partner viticulturists on their ES awareness. In addition, Martín-López et al. (2012) underlined the educational level and form (formal and experiential), the gender and the age as other factors conditioning people's awareness of ES.

VII. RESULTS PART 3: CONFRONTING KNOWLEDGES: COMPARISON OF THE LITERATURE AND VITICULTURISTS VIEWS

The confrontation of the results obtained in the literature review and during the interviews in terms of ES identification and interactions between ES and viticultural practices aims at identifying similarities and gaps between the two approaches. This comparison will set the bases of the discussion where potential valuation of this thesis work for the WCCB program will be discussed.

VII.1 ES identification

Table 6 shows the ranking of ES according to the number of times they were quoted in literature and in the interviews:

Quotes Ranking	Literature	Interviews
1	Biocontrol	Biocontrol
2	Soil Generation / Soil Fertility	Soil Generation
3	Climate regulation	Soil Fertility / Water Provision
4	Biodiversity and genetic diversity conservation	Water Quality
5	Recreational	Biodiversity and genetic diversity conservation
6	Water Provision	Aesthetic
7	Aesthetic / Water Quality	Climate Regulation
8	Wine Quality	Recreational
9	Cultural Identity	Cultural Identity
10	Natural Products Provision	Natural Products Provision

Table 6. Comparison of the numbers of quotes in literature and Interviews (when two ES are mentioned in the same rank, they received an equal number of quotes)

VII.1.1. SIMILARITIES

The literature and the viticulturists mostly valued the Biocontrol and Soil Generation and Fertility ES, being the most directly linked to the grape production. Likewise, the least mentioned articles were the cultural ES. This confirms the conclusions of Winkler and Nicholas that wine-makers generally set higher value to the provisioning and regulating services, directly linked to their productive activity, than to the cultural services. The provision of natural products in addition to wine-grapes was only mentioned by one viticulturist during the interview and in one study, confirming the secondary importance of this ES for the stakeholders of the sector.

VII.1.2. DIFFERENCES AND GAPS

The recreational ES were more valued in the literature, through the scope of sustainability While most of the vineyards visited for this study count on the Chilean sustainability certification and showed infrastructures or program for tourism activities, most of the interviewed viticulturists barely had a role in the development of tourism linked to the vineyards. Therefore, they rarely made a spontaneous link between their vine-growing activity and the recreational services. The viticulturists rather valued the aesthetic benefits of having natural ecosystems around the vineyards. Interestingly, the interviewees who most valued this ES were the ones who had comparative experiences in vineyards with few or no natural ecosystems and vineyards with abundant natural ecosystems. The cultural identity was mentioned by one viticulturist as part of the "mysticism around the harvest event" (SR_CC), nevertheless he immediately specified that industrial vineyards were not the optimal places to develop the feeling of identification of the workers. The climate regulation ES was understood at different scales in the literature and for the viticulturists: while the papers mentioned the carbon sequestration potential of the vineyards and surrounding natural ecosystems at regional to global scales (Brunori et al., 2016; Salomé et al., 2015; Tompkins et al., 2012), the viticulturists recognized the effect of the native forest surrounding the vineyard on temperature and humidity conditions at the field scale.

The water provision and quality ES were more valued by the viticulturists than by the literature. All of the visited vineyards being irrigated, viticulturists easily admitted the natural origin of the water they used in their fields and expressed similar concerns as Hannah et al. about the future water availability for irrigation (2013).

The biodiversity and genetic diversity conservation ES was recognized as important by the viticulturists and in literature. In particular, several viticulturists were sensitive to the WCCB works about the soil micro-biodiversity. Many of them expressed their curiosity to discover the results of the study about the participation of native yeasts in the wine-fermentation processes. While Viers et al. (2013) linked the sensitivity of wine-makers to ES with the importance they seem to attach to the terroir concept and the soil characteristics understanding, only two viticulturists made a link between soil biodiversity and wine tipicity. They were the only two to mention the notion of "terroir". Besides, none of the viticulturists interviewed mentioned the quality of the wine as an ES, while most of them were growing some highest quality vines of their firms. This reveals an interesting topic of dialogue and research with the partner vineyards, whose interest in finding new marketing argument for their high quality wines is very high.

VII.2 Interactions practices – ES

Figure 26 (see back page) shows the final diagrams obtained cumulating the quotes of literature and interviews. The viticulturists established many of the links made in the literature. They also identified interactions that are not mentioned in the papers analysed in the literature review.

VII.2.1. SIMILARITIES

The most valued interactions were the same for both approaches, with the interaction between landscape elements management and the biocontrol ES gathering the most quotes in both approaches. The soil management in the inter-rows and the fertilization practices were also considered in interaction with many ES.

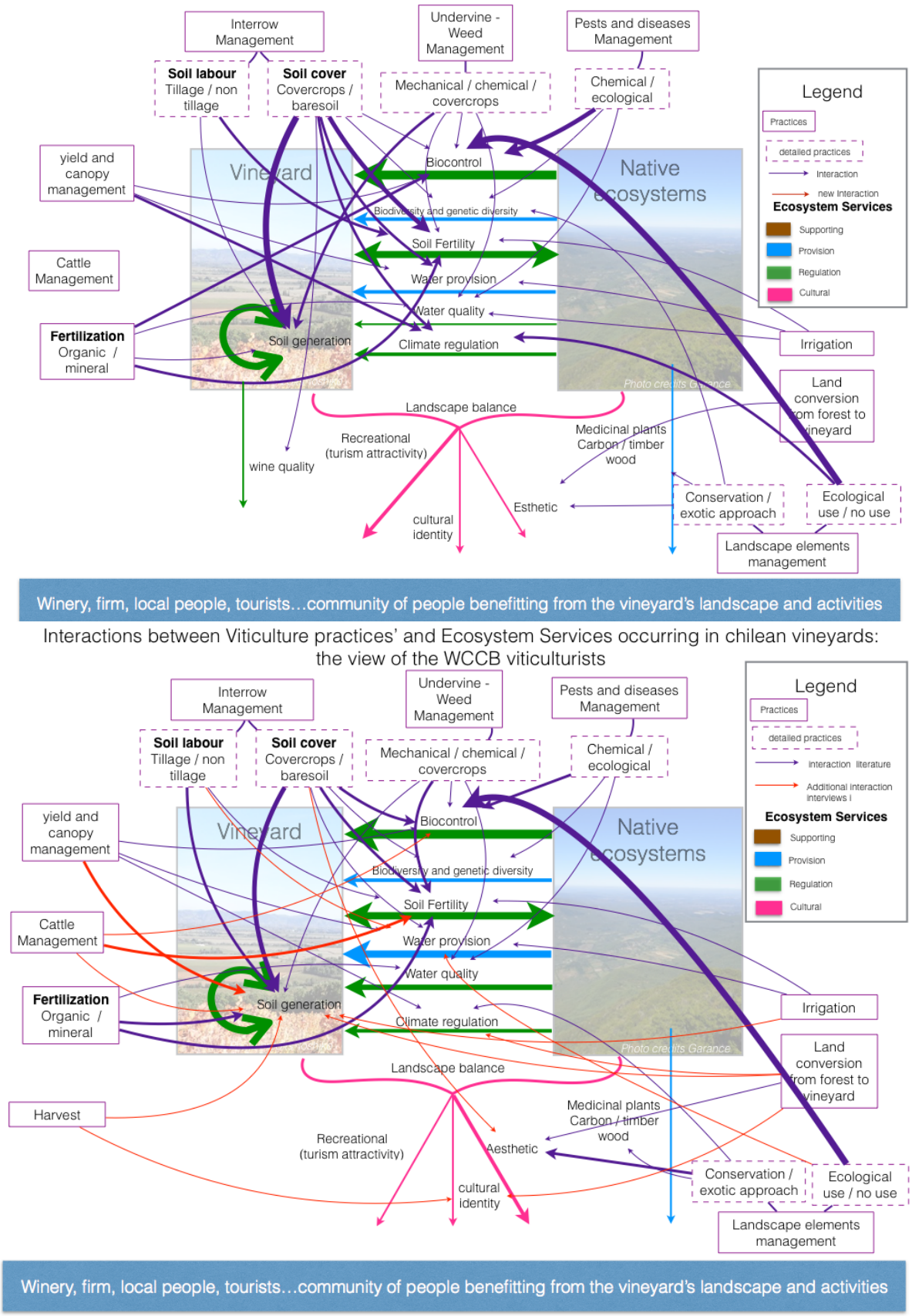


Figure 25: *Interactions between viticulture practices and ES: compared visions of the literature and the viticulturists*

VII.2.2. DIFFERENCES

The viticulturists identified most of the interactions established during the literature review, except for following interactions:

- The viticulturists didn't make the link between the management of landscape elements on their vineyards and the conservation of biological and genetic diversity ES.
- Viticulturists didn't identify any impact of their use of water for irrigation on the water quality ES.

The viticulturists established some connections between their practices and the ES that were not identified in the literature review:

- The yield and canopy management was linked to the soil generation ES through the integration of the pruning residues in almost all the visited vineyards.
- The integration of domestic animals into the vineyards management was associated by the viticulturists to the biocontrol, the soil fertility and the soil generation ES.
- Some viticulturists linked the mechanical harvest with the soil generation ES, referring to the soil compaction resulting from the harvesting machine passage. The soil compaction due to intensive machinery use on vineyards was already underlined by Lamastra et al., 2010. As one of the viticulturists mentioned, soil compaction can much more be linked to the numerous sulphur applications registered in all the vineyards than on the sole harvest passage.
- Some viticulturists admitted that the early years of new planted vineyards were moments of high soil erosion, while others mentioned the importance of including native Mediterranean forest within and around the vines plots to ensure local climate regulation. The approach of current literature of the climate regulation service is focused at regional to global scale, while the study of the local climate regulation service provided by forest in balanced vineyards could give new arguments to emphasize the conservation of native ecosystem as part of a sustainable vineyard management.

This general approach of the interactions through the diagram enables to confirms that there is a gap between the literature and the viticulturists approaches in the definition of the ES concept and its application to viticulture. Interestingly, both approaches seem to complement each other rather than to identify a "weaker" and a "stronger" knowledge.

VIII. PROPOSITIONS FOR THE WCCB PROGRAM

VIII.1 How does native biodiversity conservation serve viticulture?

VIII.1.1. CLEARING THE DEFINITIONS OF BIODIVERSITY AND THEIR APPLICATION TO VINEYARDS LANDSCAPES

The link between landscape elements management and the Biocontrol ES, most quoted by the literature, was acknowledged by most of the viticulturists. They all said to be personally convinced of the higher phytosanitary balance observed on the vineyards benefiting of sufficient natural ecosystems in the surroundings and as ecological corridors, whilst asking for more scientific evidence of the link between the global increase of biodiversity and the increase of natural biocontrol within the vineyards. This reflection seems in contradiction with the findings of this study, revealing that this interaction received the most quotes among the 30 articles studied (8 different papers), two of them being published by Chilean scientists. However, it echoes the need for more understanding of the benefits generated by conservation practices expressed by the viticulturists in Márquez Garcia (2016). On the literature side, the claim of Webb et al. (2011) for a clearer integration of the multiple services supported by natural biodiversity enhancement in the sustainable viticulture projects points out a divergence in the approach of biodiversity between research originating from agricultural sciences and from conservation sciences. Moonen and Bàrberi (2008) propose a division of biodiversity into five categories to consider when studying agricultural landscapes, exposed in table 7:

Kind of biodiversity	Area of repartition	Related ES	People interested
Cropped species	Cultivated field	Provision of agricultural goods	Farmers, agronomists
Auxiliary species and habitat	Cultivated field and ½ natural or natural surrounding habitat	Biocontrol	Agroecologists, farmers interested in agroecology
Pests species	Cultivated field	Disservice to provision of agricultural goods	Farmers, agronomists, agroecologists
Wild species producing potentially valuable goods	½ natural or natural habitat surrounding the cultivated field	Natural products provision	Subsistence farmers, conservation biologists and ecologists
Neutral species with no effect on the agricultural production	½ natural or natural habitat surrounding the cultivated field	Aesthetic, intrinsic effect on a bundle of ES	conservation biologists and ecologists

Table 7. Separation of the biodiversity in different sub-categories in the context of agricultural landscapes. According to the place, the time and the people looking at the landscape, different species may fit in the categories while one same species can be considered part of several categories. (source: Moonen and Bàrberi, 2008)

They argue that according to their discipline, scientists tend to approach agricultural landscapes with emphasis on different categories of the biodiversity without clearly mentioning it. In this study, most of the mentions to biodiversity in the interviews and in the literature referred to the mere auxiliaries and pest species. Meanwhile, the discourse of the WCCB team in front of the partner vineyards during the workshop is focusing on the differentiation of native and exotic species within the semi-natural and natural landscapes of the vineyards, enhancing the native natural biodiversity as a national patrimony prior to emphasize its functional traits in the context of the viticultural activity. The results of this study emphasize the curiosity of the partner viticulturists for "concrete" applications of the enhancement of native biodiversity. Using the classification of Biodiversity presented above, it means that they are curious to discover how native species and habitat can enter the "auxiliaries" category in their vineyards. thus underlining the interest for the WCCB program to develop research and pedagogic activities around the functional valuation of native biodiversity in the partner vineyards as a strategy to further integrate the conservation practices at the chore of the wine-making activity.

VIII.1.2. EXAMPLE OF POTENTIAL USES OF NATIVE BIODIVERSITY TO PROMOTE NATURAL HABITAT CONSERVATION ON CHILEAN VINEYARDS

Ecological processes involving native species and their habitat as auxiliaries for the pests and diseases management of the vineyards were regularly mentioned during the interviews. However, after checking, no study about the interactions between Chilean pests' natural enemies and the landscape structure was found to confirm the phenomenon observed by the viticulturists. Firstly, several viticulturists spontanously linked the low pressure of insects pests (such as Mealybug, weevil and Phytolaema hermani) with the abundancy and diversity of birds in their vineyards. The results of Jedlicka et al. (2011) making evidence of avian biocontrol in Californian vineyards are inspiring in the context of the WCCB project, where previous works of sensibilisation of the partners about avian conservation were successfully led. The recent publication of Steel et al. (2017) about the repartition of birds' species within and around some of the WCCB partner vineyards could be the base of further works emphasizing the species with functional use for biocontrol on the vineyards.

Another key issue underlined by the viticulturists is the control of rabbits and hares on the vineyards. Most of the viticulturists acknowledged the presence of sufficient native foxes and lesser-grison as the necessary condition to ensure the control of rabbits on the vineyards. Moreover, the viticulturists who chose to hunt the rabbits admit that they never managed to consistently reduce the pressure, while on the vineyards where hunting was forbidden; some viticulturists observed the increase of lesser-grison abundancy and saw their rabbit pressure decrease consequently. One of the sectorial managers with long experience of viticulture

mentioned that he perceived an increase in rabbits' pressure since the natural ecosystems surrounding the vineyards went degrading because of overgrazing. In his vineyard, recent decision to forbid animal grazing on the whole property was taken, with intention to restore the degraded natural ecosystem. This stakeholders' stories could be the base of further academic works justifying the need for biodiversity conservation on vineyards.

VIII.1.3. SOIL COVER APPLICATIONS

The effect of a vegetal cover on the inter-rows on the Soil Generation ES was the second interaction most quoted in the literature and in the interviews. 48% of the viticulturists recognized the benefits of a permanent soil cover to prevent soil erosion and slow the soil compaction.

The use of special cover crops species to enhance the soil fertility ES was also mentioned by 29% of the viticulturists, some of them including the sawing of N-fixing cover crops as a long-term fertilization strategy. 43% of the viticulturists affirmed to be observing much more insect biodiversity and macro-fauna on their vineyards since they started to install temporary or permanent vegetal covers. Finally, 10% of the viticulturists even mentioned the aesthetic benefits of a permanent soil cover inter-rows, emphasizing the coherence it brought to the vineyards' landscape. Nevertheless, further implementation of this practice is limited by the competition of the vegetal cover with vines for water resources and reduced availability of irrigation water in vineyards with thin and poor soils. Literature is abundant on the subject of cover crops, in particular in Australia and New-Zealand (Danne et al., 2010; Salomé et al., 2015; Lamastra et al., 2010; Whitelaw-Weckert et al., 2007; Orre-Gordon et al., 2013; Wheeler et al., 2005; Pino Torres, 2013; Rochard, 2014; Sandhu et al., 2016; Tompkins et al., 2012; Webb et al., 2011; Brunori et al., 2016). The propositions of Danne et al. (2010) and Tompkins et al. (2012) about the potentials of native species adapted to high hydric stress seem of particular interest and could be inspiring for the ongoing study in partnership with the WCCB program on the topic.

Tompkins even proposes the native herbaceous species as potential solution to manage the soil under the vines' rows (2010). All the viticulturists interviewed mentioned their under-vine practices as a constraint: the managers of integrated vineyards consider the use of herbicides as a "necessary harm" to their vines: although aware of the inhibitive character of the chemicals on the soil microbial life and its consequence on grapes quality and typicality, while the organic and biodynamic viticulturists deplore the high costs in machinery use or human labour linked with mechanical weeding.

Hence, proposing alternative solution involving native species could be a major step in the cooperation between the WCCB and the vineyards. Nevertheless, the implantation of native

plants inter-rows requires a time of learning and adaptation for the viticulturists, as their management is different from exotic cover crops, that may sometimes be discouraging for the viticulturists (Shields et al., 2016).

VIII.1.4. THE ROLE OF ANIMALS ON THE CHILEAN VINEYARDS

While having animals within and / or around the vineyards seem to be a common practice with multiple applications in the partner vineyards, no literature was found tackling animals and vineyards management at the same time. Moreover, the discourse of the WCCB team on the subject was rather restrictive until now.

Indeed, while the partner vineyards with degraded natural ecosystems use animals grazing around their vineyards to reduce the risk of fire in the summer, animal grazing is considered as a human induced disturbance known as one of the main source of natural ecosystems' degradation and exotic species invasion in conservation sciences (Hobbs and Huenneke, 1992). Following points came out of the conversations with the viticulturists:

- The degradation of the natural landscape through overgrazing seems to be older than the vineyards implantation. Indeed, the viticulturists who testified of their vineyards" planting experiences often testified to plant new vineyards on former rangelands in an advanced stage of soil erosion. Schulz et al. (2010) confirm the viticulturists sayings, arguing that most of the conversion of primitive natural forest in Chilean central region seemed to happen before the 1970s.
- The control of the circulation of animals on the vineyards' properties is a delicate topic: indeed, most of times, the animals grazing around the vineyards belong to the local people (often the same vineyards' workers) who made historic use of the land for grazing (Ovalle et al., 1990). In several of the visited vineyards, efforts were made to negotiate the reduction of the grazing land to some dedicated grasslands, other vineyards decided to fence their property and filtrate entrance with permanent guardians to forbid entrance to cattle and hunters. Besides, some viticulturists testified of several failed trials to plant native trees on the gulches and hills because of a lack of soil fertility and too scarce precipitations.
- The use of animals within the vineyard at key periods of the year has enabled many viticulturists to considerably reduce their use of chemical products (herbicides and pesticides). They even linked the management of animals with the Soil Generation, Soil Fertility and Biocontrol ES. They are nevertheless fully aware of the necessity to regulate animals' presence on their vine plots in order to prevent them from damaging the vines. Viticulturists are thus already sensitive to the benefits of an integrated management of animals on their vineyards.

Starting a dialogue with the vineyards on the use of animals within and around the vineyards and its interactions with the native biodiversity conservation activities may open new perspectives to optimize the benefits of ES while ensuring ecosystems restoration. It would moreover respond to an obvious research need about the use of animals in Chilean vineyards and the restoration of Chilean Mediterranean ecosystems.

Some of the partner vineyards already showed their ability to go over their communication barriers of competitiveness in order to create a common private protected area in a valley where they own neighbour properties. The diversification of the subjects tackled by the WCCB program could be backed up by new forms of cooperation, through participative reflection workshops gathering members of different vineyards around "neutral" topics such as biodiversity conservation and its applications in viticulture management.

VIII.2 Management paradigm, Chilean viticulture and Ecosystem Services: final reflections.

VIII.2.1. IS THE MANAGEMENT PARADIGM A FACTOR OF TO EXPLAIN DIFFERENT INTEGRATION OF ES ON VINEYARDS?

Today, the vineyards' management paradigms are mainly being differentiated according to their level of integration (or exclusion) of external and chemical inputs for fertilization, pests, diseases and weeds managements. According to their choices on this precise set of practices, viticulturists can apply for organic, or biodynamic certification, or consider themselves as conventional or integrated viticulturists. Hence, many studies about ES application to viticulture are led using the filter of the management paradigm and focusing on the key practices of fertilization, pests, diseases and weeds managements linked to this concept (Caprio et al., 2015; Morganstern, 2008; Reeve et al., 2005; Villanueva-Rey et al., 2014). This study enabled to get aware that the management paradigm only partially reveals the knowledge viticulturists have about the key ecological processes and ES necessary to their wine production. This knowledge is much more conditioned by the way viticulturists perceive their vineyard agroecosystems, either as a production unit or as a living entity in interaction with other ecosystems (Ohmart and others, 2008; Pino Torres, 2013; Winkler and Nicholas, 2016). Hence, if the management paradigm may reveal part of the logic and perceptions laying behind viticulturists' awareness of the ES concept, it may overcome practices of major importance in the integration of ES into vineyards' management. In the WCCB context, the interest is to generate partners' perception to the native ecosystems surrounding their vineyards and how these ecosystems interact with their vineyards agroecosystems. As a consequence, the team may get greater results if they focus on generating personal awareness among the viticulturists about the set of practices that are tightly linked to the provision of ES and the conservation of native biodiversity.

VIII.2.2. THE IMPACT OF CERTIFICATIONS ON AWARENESS AND PRACTICES

Among the viticulture practices identified in this study, the inter-rows' soil labour and cover, the landscape elements, the presence of animals and the yield and canopy managements seem moderately to completely disconnected from the management paradigm's definition, while highly conditioning the integration of biodiversity at all scales of the vineyard. Biodiversity conservation around and within the vineyards is highlighted as an essential condition to the provision of key ES (Altieri and Nicholls, 2002; Hannah et al., 2013; Orre-Gordon et al., 2013; Rochard, 2014; Viers et al., 2013). In spite of this, current organic and biodynamic certifications present reduced requirements on the topic: for example, in the document presenting the criteria for organic plant production published in 2014 by the European main organic certification organism Ecocert (that serves as a reference for the organic certification organisms like BCS or IMO identified in this study), no mention to biodiversity is made. Likewise, despite the presence of a paragraph about biodiversity conservation in the sustainability code published by the organization Wines of Chile in 2008, no obligatory criteria are based on this paragraph in the requirements for the sustainability certification. This lack of exigence from the certification organisms may be a reason to the relative lack of awareness and interest of the viticulturists for biodiversity and landscape elements management underlined in Webb et al. (2011). However, the viticulturists were unanimous in saying that the certifications were not a source of awareness for them. They rather argued that they applied for certification once they had already experimented changes in their environmental awareness through personal and corporate experiences. Further research on the actual drivers of viticulturists' sensitivity for environmental issues would enable the WCCB team to better adjust their approach of the cooperation with vineyards in order to reach a higher impact on their practices.

VIII.3 putting ES knowledge into practice in Chilean vineyards: next steps

VIII.3.1. FIND NEW DRIVERS OF MOTIVATION TO FURTHER INVOLVE THE PARTNERS IN BIODIVERSITY CONSERVATION

Santiago-Brown et al. (2014) underline that "environmental issues were not the main drivers for the conception of sustainability assessment programs for viticulture" (p.2060). This is particularly true in Chile, where the sustainability code was created under pressure of the main international retailers (Santiago-Brown et al., 2014b) and where most of the wine is being produced by large firms with clear priority on economic profitability over environmental and conservation emergency. While the WCCB position until now has been to raise awareness of vineyards managers and workers on the general importance of biodiversity conservation on their territory, the team is now at a key moment of its development, disposing on the quality of knowledge of the academic research, the capacity of pedagogic transfer to the stakeholders, while having established relationships with their partners solid

enough to receive their attention and motivate further will to cooperate. This study enabled to set the scene of the knowledge that WCCB partner viticulturists have of the ES concept and how they perceive it applies to their vineyards. Thus, the next step could consist in co-designing research projects with the partners, which results could generate an immediate impact on viticulture practices towards an increased room for conservation. among the multiple ways of studying ES applied to vineyards, the use of economic indicators to measure the efficiency of some ES, such as biocontrol, can be an efficient tool to show evidence of the direct benefit viticulturists get from natural ecosystems while “speaking their language" of costs optimization. Finally, the program could play an important role in the already happening expansion of the vineyards further south, by helping the viticulturists to optimize ES provision in the design of their vineyards’ landscape. Santiago-Brown et al. (2014b) also underline the importance of the way that the program team members were involving the stakeholders in the project evolution over time, as well as the efficiency of the program perceived by the stakeholders in order for sustainability projects to be successful on the long run. Therefore, next paragraph underlines the potential benefits of the integration of the partners into a more participative research activity in the future.

VIII.3.2. EFFICIENCY OF THE PARTICIPATORY APPROACHES

The ES concept was designed for decision makers to better integrate natural ecosystems in landscape planning from local to global scale. While obvious efforts were made to assess the value of ES and its evolution at major scales in parallel to the land-use evolution (Costanza et al., 2014; Turner et al., 2016), urgent research efforts are needed at regional and local scales to transfer and apply the cumulated knowledge about ES (de Groot et al., 2010)The development of participative research tools and the greater implication of concerned stakeholders in landscape management decisions are essential to accelerate ES integration at all scales (de Groot et al., 2010; Müller et al., 2011; Turner et al., 2016). In central Chile, current absence of a national or regional approach to landscape planning makes the individual land-owners the most powerful stakeholders for land use decisions.

Among the scientific papers reviewed in this study, three main approaches of the ES applied to viticulture were identified: the empirical evidence approach, the resource management approach, and the sustainable viticulture projects approach. While the two first types of studies are often led without major stakeholders’ participation and suffer from a lack of recognition from the wine-makers, the third often involves the viticulturists in a participatory way, using self-assessments, workshops or certification tools and show concrete impact on their practices. They encompass a high educational component, where the application of ES to the vineyards management is considered as part of the tools to achieve the environmental part of sustainability (Ohmart and others, 2008). On the academic approach side, some

experience of successful cooperation between academic researchers and wine-makers are also emerging. For example, the experience of Pain et al. (2016) in a French conservation project applied to viticulture showed a radical change in the involvement of the wine-makers once they started to be integrated in the co-design of the research project. These stories reveal the high potential of shifting the scientific methodologies towards more inclusion of the concerned stakeholders. The WCCB team has the objective to reach a faster pace in increasing the awareness and engagement of their partners for native ecosystem conservation. As they are of growing use in agroecology scientific development and extension (Warner, 2008), participative methodologies involving the stakeholders in research projects designs and knowledge production could be a source of inspiration for the WCCB team, although careful consideration of the communication barriers between the Chilean wine-making firms would be necessary to ensure the involvement of the partners in a collective and collaborative approach to research.

IX. CRITICAL VIEW ON THE METHODOLOGY

IX.1 An innovative method to assess ES knowledge

This study adopted an innovative approach to ES study, crossing academic knowledge of the wine-making world and local experiential knowledge of the Chilean viticulturists. Realized in an interdisciplinary context, this exploratory study was characterized by a large freedom in the methodology choice, resulting in some difficulties to value the results obtained.

The self-designed methodology employed for this study was inspired from ES social valuation (through the identification of ES applied to viticulture by literature and stakeholders) and ES measurement (through the evaluation of the interactions between ES and viticultural practices) studies. Contrary to other social valuation studies, based on surveys where a list of ES is presented to the interviewees (Winkler and Nicholas, 2016; Martín-López et al., 2012; Sandhu et al., 2007; Zoderer et al., 2016), the approach of this study was to identify which ES were already integrated in the viticulturists' representation of their vineyards and which ES were not. Interestingly, while the spontaneous definition of ES seemed a hard exercise for viticulturists, they appeared to feel much more at ease identifying ES in the context of the interactions they perceived between their viticultural practices and the natural ecosystems. Cáceres et al. (2015) presents a similar approach: they led numerous semi-structured interviews focusing on the concrete use people make of their surrounding ecosystems to describe the social value, without presenting any list of ES nor mentioning the concept in forehand. Their study led to further links between social valuation of the ES and biological processes underpinning them. Despite the necessary subjectivity of the interpretations of this study (led without any cross-analysis or peer-review of the coding

system), this approach seems appropriate to get a global overview of the integration of the ES concept and its actual and potential applications at local scale. In a context where conservation research seeks for more efficiency and direct impact on decisions at all scales (Laurance et al., 2012), this approach could be a good tool to generate new research lines closer to the stakeholders' reality and therefore more susceptible to generate a high impact on their conservation attitude.

IX.2Classifications of viticulture practices and Ecosystem Services

The classification of viticultural practices was designed on the base of readings about viticulture (Gil and Pszczolkowski, 2007; Pino Torres, 2013; Reynier, 2016) and conversations with specialists previous to the interviews. It resulted to be quite well adapted to the conversation with viticulturists, who easily understood and responded homogenously to the questions about each practices family.

The choice of ES was based on the conceptual framework of the MEA, as well as the detailed classification proposed by de Groot et al. (2010) in parallel with the literature applying ES to the wine-making world. It was hard to stick on one definition for each ES, the underlying debate of whether ES are the result of mere natural ecological processes or if they can also be the result of the interaction of human and natural processes maintained a fuzzy understanding of the concept during the thesis. Moreover, the intertwined character of the ecological processes leading to some ES such as soil fertility, water provision and soil generation made their differentiation hard. This led to a high subjectivity in the interpretation of viticulturists' description of some ecological processes.

IX.3Design and use of the conceptual diagram as the base for analysis

The choice of the conceptual diagram as the base of the comparative reflection about the findings of the literature review and the interviews accomplished its goal to offer a visual support summarizing the high quantity of information and facilitating the discussion. Despite the high numbers of arrows, the different entities of the conceptual framework – the practices, the ES, the different ecosystems, the community benefiting from the wine and the vineyards' landscapes – were easily differentiable. While the structure of the population of interviewees didn't allow the application of some statistical analysis to further test the hypotheses presented in this study, the qualitative analysis and the visual structure of the diagram enabled to emphasize links between the ES and some viticultural practices that seem to have low dependence on the management paradigm. These findings can set the bases for a research on the actual impact of the viticultural practices on ES integration in the vineyards. The conceptual diagram also suffered from following limits:

- The flow of ES from natural ecosystems to vineyards agroecosystems illustrates the perception enhanced by the WCCB team. In spite of this representation, the ES considered in this study happen at many more scales than the landscape proposed in the conceptual diagram, from the soil microcosm within the vineyards' plots to the atmospheric carbon content at global scale.
- The "interactions" between viticultural practices and ES are represented with one-headed arrows pointed from the practice to the ES, symbolizing the impact of the practices on the ES more than the interactions between the two. This choice was made in order to emphasize the WCCB approach, underlining the natural ecological processes as the centre of the research interest. However, this study considered the interaction between natural ecological processes and viticultural practices more than the mere impact of the practices on ecological processes. It would have been more accurate to represent these interactions with two-headed arrows.
- The analysis of the interviews resulted more in an assessment of how the viticulturists' knowledge fit into the conceptual framework proposed by the literature review than an actual representation of their collective and individual perceptions of the ES concept and its application to their vineyard.

It will be necessary to consider the limits of the diagram when transferring the results to the vine-growers.

IX.4Interdisciplinarity: recognizing the bias of a non-specialist approach

The choice of a clearly qualitative methodology in the context of a laboratory of ecology was not easy to value. Indeed, the lack of solid theoretical bases and support on qualitative research design resulted in difficulties to choose the right sample of viticulturists for the interviews. Moreover, the definition of the interview analysis criteria and the interpretation and qualitative analysis of the data was led in total autonomy, thus limiting the reflection to one own subjective perception. Increased communication with the professors with sociological competences at the beginning of this thesis work would have increased the reliability of the method of analysis and sampling. Moreover, the analysis of this study were based on the number of ES and interactions recognized by each viticulturist or article. Nevertheless, the dependence of these two variable was not considered in the analysis while they are highly depending on one another. The further development of this methodology would therefore require numerous adjustments to be suitable for proper sociological and statistical analysis.

X. CONCLUSION

This thesis work was led in the context of the Wine, Climate Change and Biodiversity program, coordinated since 2008 by Chilean researchers in cooperation with the biggest wine-making firms of the country. It aimed at gathering and comparing the existing scientific and experiential knowledge about the Ecosystem Services concept applied to viticulture and its application in interactions with the different viticulture practices identified in the Chilean vineyards context. A literature review of thirty articles from the whole world and 21 semi-structured interviews were led with the viticulturists from the partner firms of the. WCCB program Results analysis were structured around the hypotheses that 1) a knowledge gap separates the scientific knowledge collected in the articles from the experiential knowledge gathered throughout the interviews and 2) the variation of experiential knowledge between the viticulturists could potentially be explained by their management paradigm, defined as their personal qualification of the practices they apply on the vineyards they are managing. Results were compared using a conceptual diagram where the number of mentions to each ES and interaction were emphasized. Both approaches most valued the same ES, corresponding to the regulating services most important for the grapes production. Overall, conventional viticulturists seemed to identify less ES and interactions than the viticulturists with other management paradigms. Nevertheless, if the management paradigm defines clear differences in the viticulturists' choices for some practices, like fertilization and weeds management, it has a reduced influence on many other practices. For example, the organic, biodynamic or sustainability certifications seem to have reduced influence on the way landscape elements are managed within and around the vineyards, while this practice is determining the provision of sufficient biocontrol agents on the vineyards among other ES. Finally, the global perception that viticulturists have of their vineyards doesn't necessarily rely on their management paradigm, while it highly influences the way they integrate natural ecosystems and the ES in their practices. This study also permitted to identify several potential research topics to generate locally appropriate knowledge with direct impact on the viticulturists' behaviour towards native ecosystems and further involvement in native biodiversity conservation: the study of the ecological interactions between native vegetation within and around vineyards with the natural enemies of several key pests of the vines; the potentials of native soil covers on the whole vineyards' surface in a context of water scarcity; and the integration of domestic animals as ecosystem restauration agents. The WCCB team has the potential to develop an efficient participative action research network with its partner vineyards, based on the organization of new pedagogic workshops and the integration of participative methodologies to co-design new research projects. Further development of the project in this direction can respond to high research needs regarding the application of the

ES concept at local scale (de Groot et al., 2010; Müller et al., 2011) while achieving concrete success in the conservation of the Chilean Mediterranean climate (Laurance et al., 2012). The WCCB team is currently establishing a dialogue with the Chilean agriculture and environmental ministries. Their expertise about the way to integrate biodiversity conservation behaviours into one of the biggest agro-industry of the country could serve as a base for the creation of a national policy in favour of the native biodiversity conservation within the agro-industrial development.

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APPENDICES TABLE OF CONTENT

APPENDIX I: presentation of the Articles red for the literature review

Bibliography reference	Title of the article	Type of article
Altieri and Nicholls, 2002	The simplification of traditional vineyard based agroforests in northwestern Portugal: some ecological implications	Scientific paper
Barbosa and Godoy, 2014	Conservación biológica en viñedos: conceptos claves y actividades prácticas.	Practical guide for WCCB vineyards
Brunori et al., 2016	Sustainable viticulture: The carbon-sink function of the vineyard agro-ecosystem	Scientific paper
Caprio et al., 2015	Organic versus conventional systems in viticulture: Comparative effects on spiders and carabids in vineyards and adjacent forests	Scientific paper
Castañeda et al., 2015	Comparison of soil microbial communities inhabiting vineyards and native sclerophyllous forests in central Chile	Scientific paper
Danne et al., 2010	Effects of Native Grass Cover Crops on Beneficial and Pest Invertebrates in Australian Vineyards	Scientific paper
Elsawah et al, 2015	A methodology for eliciting, representing, and analysing stakeholder knowledge for decision making on complex socio-ecological systems: From cognitive maps to agent-based models	Scientific paper
Etcheverry, 2014	Revisiting the Terroir Concept: how to include Ecosystem Services in the Notion of Terroir in Mediterranean Vineyards?	Msc Thesis
Griesser et al., 2016	Management concept to promote biodiversity-linked ecosystem services in vineyards (Project PromESSinG)	Seminar report
Hannah et al., 2013	Climate change, wine, and conservation	Scientific paper
Jedlicka et al., 2011	Avian Conservation Practices Strengthen Ecosystem Services in California Vineyards	Scientific paper
Lamastra et al., 2010	Enhancing the Ecosystem Services in Viticulture Farms: Approaches towards a Sustainable Management	Scientific research book chapter
Ohmart et al., 2008	Innovative outreach increases adoption of sustainable winegrowing practices in Lodi region	Scientific paper

Orre-Gordon et al., 2013	Viticulture can be Modified to Provide Multiple Ecosystem Services	Scientific research book chapter
Pino Torres, 2013	Manual de Viticultura Orgánica	Practical guide for organic viticulture in Chile
Priori et al., 2015	ReSolVe project-Restoring optimal Soil functionality in degraded areas within organic Vineyards	Seminar report
Rochard, 2014	Biodivine: Guide Technique. Pratiques et aménagements favorables au maintien et à la gestion durable de la biodiversité dans les paysages viticoles	Technical guide for viticulture in Europe, outcome of the LIFE + BioDiVine research project
Salomé et al., 2015	The soil quality concept as a framework to assess management practices in vulnerable agroecosystems: A case study in Mediterranean vineyards	Scientific paper
Santiago et al., 2014	Transnational Comparison of Sustainability Assessment Programs for Viticulture and a Case-Study on Programs' Engagement Processes	Scientific paper
Sandhu et al., 2016	Mainstreaming Ecosystem Services into Future Farming	Scientific paper
Steel et al., 2017	Patterns of bird diversity and habitat use in mixed vineyard-matorral landscapes of Central Chile	Scientific paper
Tompkins et al., 2012	Enhancing Ecosystem Services in Australasian Vineyards for Sustainability and Profit	Scientific research book chapter
Tompkins, 2010	Ecosystem services provided by native New Zealand plants in vineyards	PhD Thesis
Trouvelot et al., 2015	Arbuscular mycorrhiza symbiosis in viticulture: a review	Scientific paper
Villanueva et al., 2014	Comparative life cycle assessment in the wine sector: biodynamic vs. conventional viticulture activities in NW Spain	Scientific paper
Webb et al., 2011	Sustainability practices and programs in New World vineyards of the Mediterranean biome	Scientific paper
Wheeler et al., 2005	Vineyard floor management improves wine quality in highly vigorous Vitis vinifera 'Cabernet Sauvignon' in New Zealand	Scientific paper
Whitelaw-Weckert et al., 2007	Permanent swards increase soil microbial counts in two Australian vineyards	Scientific paper

Winkler and Nicholas, 2016	More than wine: Cultural ecosystem services in vineyard landscapes in England and California	Scientific paper

APPENDIX II : Interview guide

SPANISH :

Presentación personal:

Hola, me llamo Garance y me integré al equipo de investigación del proyecto VCCB para realizar mi tesis de magister en Agroecología.

Muchas gracias por darnos de su tiempo, esperamos que esta discusión sea entretenida para usted como para nosotras. La entrevista debería durar alrededor de 45 minutos, para poderla analizar luego con su acuerdo, grabaremos todo lo que se va a decir. Cuente con nuestra discreción y el uso exclusivo del contenido de nuestra conversación para mi estudio. En ningún lugar le nombraremos ni a usted ni a su viña al presentar los datos.

Presentación entrevista:

El estudio que estamos haciendo se enfoca en las relaciones que existen entre el bosque esclerófilo y sus campos de viñas.

¿Tiene usted preguntas o dudas sobre el desarrollo de nuestro encuentro?

Entrevista:

1. Presentación personal (objetivo ganar confianza y conocer mejor a la persona)

¿Cuál es su función en la empresa xxxx?

¿Cuándo y cómo llegó a este cargo? ¿Cuál a sido su recorrido profesional antes de llegar a este puesto?

2. Concepto aplicado de Servicios ecosistémicos

¿Usted ya escuchó la expresión “Servicio ecosistémico”?

¿Que opina usted de la definición del concepto que dice que los SE son “servicios entregados al hombre por la naturaleza?

¿Cómo siente usted que este concepto se aplica a su campo vitícola? ¿Qué servicios ecosistémicos siente usted que *el bosque* dentro y alrededor de su campo le entrega?

3. Paradigma de manejo y vínculo con las prácticas

¿Que manejo tiene usted para yyyyy (ir revisando las prácticas)? ¿Cómo piensa usted que esta práctica interactua con los servicios que le da el bosque al rededor?

¿Cómo cualificaría usted su tipo de manejo, entre convencional, integrado, orgánico o biodinámico?

¿Cuenta usted con una(s) certificacion(es) para su campo?

¿Qué certificaciones tiene usted para la producción de su campo?

¿Usted participó en persona al taller del programa VCCB sobre la biodiversidad?

Memo personal:

SE a mencionar:	Prácticas:
• Biocontrol • Provision organismos de fermentación • Provisión de agua • Calidad de agua • Fertilidad de suelo • Generación de suelo • Regulación clima • Provisión plantas medicinales y materia combustible	• Manejo de rendimiento (maquinaria y residuos) • Cosecha (maquinaria y residuos) • Fertilización • Manejo entre-hileras y bajo vides • Manejo de plagas y enfermedades • Manejo de malezas • Irrigación • Ganado • Elementos de paisaje (≠ viña)

ENGLISH :

Personal presentation:

Hello, my name is Garance, I integrated the research team of the WCCB project in order to realize my Master thesis in Agroecology.

First, I thank you a lot for the time you accepted to offer to us, I wish this dialogue will be as fun for you that it will for us. The interview shall last around 45 minutes and in order to analyse it afterwards it will be recorded. Count on our complete discretion and the exclusive use of the record in the context of my study. In no case will we name you nor your firm while presenting the results of the study.

Interview introduction:

Our study focuses on the relationships that exist between the vineyards you manage and the forest that surrounds it. I will ask you some questions to which you shall feel completely free to answer with what you know and feel about the topic. We are not assessing how much you know nor judging your opinion, our interest is in better understanding how you perceive your work in relationship with the forest.

Do you have any question about the process of this interview?

Interview:

1. General questions

What is your work consisting in here?

When and how did you get to this work? What professional experience did you have before coming here?

2. Applied concept of Ecosystem Services

Have you already heard about the concept of “Ecosystem Services”?

What is your opinion about the definition that says that ESS are “services provided from Nature to humans”?

How do you feel this concept applies to your vineyards? What Ecosystem services do you feel you get from the sourrounding forest?

3. Viticultural management paradigm and link with the practices

What do you generally do to xxxx (name one type of practice)? Why? How do you think this interacts with the services that the forest provides to the vineyard?

How would you qualify the kind of management you apply on the vineyard between conventional, integrated, transitioning, organic and biodynamic? Do you have any certification for your vineyard? If yes, can you name them to me?

Personal memo :

ES to mention	Practices:
• Biocontrol • Genetic diversity through fermentation microorganisms provision • Water provision • Water quality • Soil Fertility • Soil generation • Climate regulation • Medicinal plants and other natural productrs provision	• Yield and canopy management) • Harvest • Fertilization • Interrows managements (soil cover and labour) • Undervine / weeds management • Pests and diseases management • Irrigation • Cattle management • Landscape elements (non cropped species on vineyard)

APPENDIX III : example of an interview transcription and analysis

1	**G:** entonces R., la primera pregunta que tengo para usted es que se presente un poco, diciéndome su cargo en la empresa, y cuales responsabilidades tiene aca, desde cuanto tiempo? **RZ:** ya yo soy R.Z. llevo acá 5 años en Caliterra y yo soy el enólogo jefe de Caliterra, yo hago los vinos, pero también como enólogo tengo una participación activa en cuanto al manejo del viñedo y obviamente decisiones de cosecha y decisiones también sobre un poco la estrategia de marca o hacia donde vamos: entonces de una cierta manera también tiene que ver con el manejo cultural de la viña.	**PP – position in the firm** Main oenologist of the winery for 5 years. responsible for the wine-making but also has to do with vineyard's management: participate to harvest and decision making of marketing and production strategies.
2	**G:** vale. Y como llego a este cargo? Cual fue su recorrido… **RZ:** yo empecé en Francia…bueno fue largo, yo llegue de Francia el 2007 y entre a viña Errazuriz inmediatamente, y como Caliterra es parte del Holding yo empecé como Enólogo asistente y de a poco subiendo hasta llegar a Enologo jefe…de esta marca. Y entre acá en Septiembre 2011. Después de haber en el fondo trasladado entre viña Errazuriz como marca Errazuriz, me hice cargo en el fondo de este proyecto Caliterra.	**PP – background** started to work in France. Came back to Chile in 2007 and started right away to work for Errazuriz vineyard. Went climbing the steps and participated to the creation of Caliterra as chief eonologist in 2011.
3	**G:** perfecto, gracias…y en el día día…en que decisiones de campo participa usted en particular? **RZ:** a ver, en el día-día…digamos que por ejemplo hoy en día estoy participando de las decisiones de poda ponte tú de cómo podar. Después durante el periodo ya de trabajo en verde vamos…hago mas que nada una pega, un trabajo como de…supervisión indirecta, porque no soy el responsable directo pero sin embargo yo hago requisitos. Supongamos yo digo "no me gusta como esta esto, hagamos algo mejor" o "me gusta mucho esto, muy bien". Es un poco una supervisión de este tipo. Sugerencias, "creo que esto hay que manejarlo de otra manera"…hago un trabajo de acá lo llamamos abastecimiento de uva todo el tema de cómo poder cumplir con el portafolio de vinos por lo tanto, hago un poco el balance de la uva que tenemos en términos de calidad, en términos de cantidad para ir definiendo los caminos a seguir en el viñedo y también en otras viñas que tenemos afuera. Y bajo este diseños trabajamos el viñedo…trabajo, he tenido también una intervención en el tema de sustentabilidad en esta viña Caliterra, en términos de un poco de la directriz a seguir, de cómo ir avanzando. Participo obviamente en todo la sustentabilidad de bodega, pero también un poco no dirigiendo pero si aconsejando el tema de la sustentabilidad en el viñedo. Entonces, parto con la poda,	**PP – position in the firm** day – to – day responsibilities: participate to the pruning decision, making the link with the different wine categories' objectives (have 6 different wine qualities) his work is more of "external supervision" for the production Responsible for the external grape – provision Motor of the sustainability "training" and reflection in the vineyard

	sigo con el manejo técnico junto con R. S. en la época en verde; después en los momentos de cosecha yo tomo decisión de cosecha de cada cuartel cuando se cosecha y la forma de cosecha, y un poco vamos dando vuelta así en el año. **G:** vale. Cuántos niveles de calidad tiene esta viña? **RZ:** acá tenemos…5 a 6 niveles de calidad. Desde ícono hasta granel. **G:** vale. Y todo se concentra en este..esta zona? **RZ:** no toda la uva que tenemos proviene de acá, pero este es nuestro fuerte y la mayoría de los vinos tintos salen de acá, tenemos algún abastecimiento externo para poder completar lo que nos falta pero...y los vinos blancos son totalmente externos acá no tenemos ningún blanco este no es un terroir de blanco y ahí blanco es Casablanca, Leyda y incluso un poco de Itata también.	
4	**G:** y para hacer los blancos y…o sea completar, trabajan con productores más pequeños? **RZ:** productores pequeños, si, productores pequeños, productores de largo plazo, productores de corto plazo, algunos son grandes. Por ejemplo tenemos un contrato a 20 años que termina en 2020 con un productor de Casablanca que son alrededor de 30 ha nuestras. Pero son…es un viñedo de 300 ha entonces esto es un productor grande…tenemos contratos con productores pequeños que son solo nuestro digamos la compra. Hay un poco un mix…a mi me gusta más el concepto de trabajo con productores pequeños pero hay alguno "héritage" o sea estamos terminando algunos contratos que aún no terminan, pero la idea ojalá en el futuro es tener algo más personalizado, con pequeños productores, y estos pequeños productores trabajan en conjunto para salir sopongamos…en conjunto que sea sustentable que se haga un manejo más acorde a lo que es este viñedo.	**Actors – small producers** Work with some small or medium producers with medium and long-term contracts (20 years of contract for a white wine grape producer in Casablanca)
5	**G:** perfecto. Otra pregunta R.: que significa para usted, o ha escuchado ya el termino de SE? **RZ:** lo he escuchado por la Olga [risa] el concepto de servicio de Ecosistema, o ecosistémico, pero creo que me falta información también un poco. Yo entiendo SE es como…como **ayudarse en el fondo, en lo natural, la naturaleza todo lo que da el lugar en la producción digamos.** Algo así.	**PP – def ESS** "Get helped from the natural ES, from nature for all the production steps"
6	**G:** perfecto. Y cómo siente que acá, vamos a enfocarnos en este campo que usted conoce mejor, maneja etc…cómo lo ve acá, si es que lo ve aplicarse dentro de este campo?	**PP – feelings and opinion** Chile is very behindhand in term of sustainability. Preocupation started because of OECD pressure, threatening to expulse Chile from the

	RZ: yo siento que acá, estamos en un nivel medio-alto para lo que es Chile pero muy por debajo de lo que debiéramos ser. En Chile yo encuentro que estamos muy atrasados en termino ecosistémico…cualquier cosa digamos que tenga que ver con el medio ambiente en Chile está muy atrás. Si uno se remonta al histórico de Chile, yo creo que hace 4 años ha habido una real preocupación, o políticamente se dice que hay una preocupación por el respeto al ecosistema pero antes de esto no hay ninguna preocupación y yo creo que la preocupación se da más que nada por las presiones de la …de la OECD, que nos están empezando a exigir como país sino puede que seamos el primer país que saquen de la OECD y esto, creo que sería vergonzoso. **G:** a este punto lo dijeron? **RZ:** están metiendo presión. Entonces Chile se está empezando a preocupar pero de una forma muy…política, yo creo que falta una visión más empresarial con respeto al medio ambiente y Caliterra no escapa a esto. Pero sin embargo ha tenido desde el año 2006 ha tenido una visión de ser una marca amigable con el MA. Uno puede decir que nace por preocupación de las personas o también por un discurso de marketing, pero al final yo diría que…este proyecto acá es un proyecto muy realizado por las personas in situ, no tanto por el dueño que exige más que nada producción y todo. Y las personas acá siempre han tenido un perfil de preocupación por el MA. Y esto cómo se ha hecho la bajada digamos al tema ecosistémico…se trata de maximizar uso de…digamos se ha tratado de maximizar el uso del ecosistema pero con un conocimiento M.U.Y. básico.	board if the country didn't get a political interest in the Environmental management. In the wine-sector, preoccupation started slowly since 2006, but as a bottom-up movement more than top-down, as the vineyards' owners want production more than anything. Very stimulated by the marketing approach and the will to develop a "greener image" of brand. in Caliterra, they started with the VERY basic knowledge they have
7	Entonces yo te diría que hemos aprendido mucho con la Olga de que al final hemos cometido errores,	**VCCB** learnt a LOT from Olga about does and don't of conservation
8	ponte tú al tener los caballos, el tratar de poner cultivos entre-hileras exógenos, exóticos, que al final uno cree que está haciendo un bien, y se hace más un mal que un bien al lugar. Tratar de implantar enemigos naturales exógenos también…por lo tanto yo creo que si uno habla de el uso del ecosistema in situ, nos falta mucho. Y de hecho por esto yo propuse este trabajo con las malezas, en el fondo es tratar de descubrir lo que tenemos en los cerros y tratar de que esto bajarlo al mínimo para tener una continuación del ecosistema de los cerros a los viñedos pero esto es un comienzo hacia lo que uno debiera hacer.	**ESS – biocontrol** indirect : would like to try and use native natural enemies and native species as cover-crops
9	**G:** cuando usted menciona el proyecto de las malezas… **RZ:** de las hierbas nativas digamos.	**Actors**

	G: si, pero hay un proyecto atrás de… **RZ:** si estamos trabajando en un proyecto más largo, sobre el estudio de la…de la digamos de la población de hierbas naturales que tenemos acá en los cerros. Y tratar de ver si algunas de estas se pueden cultivar entre comillas y sembrar en el viñedo para en el fondo competir con las hierbas exógenas que están introducidas, y a la vez tener un profit, un provecho para el viñedo. **G:** mmmh…y trabajan con Carlos Pinos o no? **RZ:** si, exactamente.	work with Carlos Pino for the Research project about native cover-crops in the interraw.
10	**G:** muy bien. Entonces ahora actualmente tiene cobertura entre-hilera en todo el viñedo? **RZ:** no. Tuvimos el…es que nosotros a parte tuvimos un proyecto orgánico, que el proyecto orgánico eran [muestra en el mapa] todo esto, esta parte que estoy poniendo en circulo, la parte del proyecto orgánico desde el año 200…creo que fue el 2007 hasta el 2013. Y se llegó a hacer producción de vino orgánico, y pero se acabó ahora. Esta producción de vino orgánico era bien a la chilena. Con la certificación de IMO, todo legal para ser orgánico pero trayendo cosas de afuera, sembrando dedal de oro ponte tú, implantando enemigos naturales de afuera y vendiendo muy barato. Por esto no fue sustentable económicamente. Porque la producción era más cara y se vendía muy barato entonces… **G:** era más cara por el tipo de insumos que se usaban? **RZ:** no, porque la producción orgánica es más cara de por si po tú no puedes fertilizar, tienes que aplicar compost, todo es más manual, la producción baja mucho, lo que es muy bueno porque mejora la calidad, pero…pero después si tu no vendes a un precio que justifique todo el esfuerzo no se paga. Y en esta viña no vieron este beneficio y lo cortaron. Pero…se cortó esto tratando, y	**MP – integrated** did an organic experiment between 2007 – 2013 but it was too expensive and bad-managed to be profitable. preferred focus on getting the whole vineyard sustainable and integrated than only one part organic and the rest conventional
11	se pensó “ocupemos este dinero mejor en que todo el viñedo sea bien sustentable” y empezar a emplear el tema de los corredores ecológicos, tratar de aumentar los cultivos entre hileras. Esto no pasó, por suerte, porque por desconocimiento nosotros poníamos cultivos exógenos, y en ningún momento pensamos que esto era lo ideal pero después… **G:** qué cultivos pusieron? **RZ:** un montón, avena, trébol, dedal de oro y otros más que yo ya no me acuerdo. Ya no me acuerdo pero hubo varios que se pusieron que no son de acá.	**Practices – I&U** Used to saw covercrops, but stopped when they got aware that they were strongly impacting the ecosystem putting exotic species
12	**G:** y se dio cuenta de algún efecto en especial…hacia el bosqu…o sea hacia la parte natural o…?	**Practices – cattle**

	RZ: no especificamos no es que uno pueda decir que estamos llenos de dedal de oro en los cerros yo los cerros los veo bien…protegidos de esto. Porque en el fondo a ver cómo es el manejo de nosotros: lo único que tiene contacto con los cerros son los caballos. Pero los caballos en el periodo de invierno cuando están en el viñedo, están sólo en el viñedo. No están en los cerros. Hay una separación entre los cerros y el viñedo. Y en verano cuando se seca todo esto, bueno cuando empieza a brotar la viña, los caballos se van al cerro. Y nunca tocan la viña. Entonces hay una estacionalidad en la cual si, uno puede decir hay un pequeño porcentaje de cruce pero no es que estén todo el tiempo viniendo…ahí si que sería un desastre.	have horses on the field: spend winter in the vineyard, eating the grass there, spend summer on the hills
13	Entonces si uno recorre los cerros que lo he hecho, no hay muchas plantas exógenas…yo creo que se mantiene bastante el…lo que es natural de los cerros. Pero acá en el viñedo se perdió yo creo gran parte de lo que era natural y hay muchas malezas…que también acá abajo que esto no es nuestro, solo llegó hasta acá…y ahí tienen trigo, tienen otros cultivos que yo creo van avanzando hacia acá. **G:** vale. Entonces acá, su manejo entre-hileras? **RZ:** es totalmente convencional. Con herbicidas con…que a mi no me gusta pero. Y de hecho parte del proyecto esto de las hierbas es para tratar de eliminar herbicidas. Para mi lo ideal sería eliminar herbicidas y las malezas que crezcan aplastarlas o tratar de mantenerlas pero aplastadas. Pero bueno ahí hay todo un tema de desarrollo que está en camino pero falta todavía. Hoy día se maneja con herbicida y cortando. **G:** qué tipo de herbicida usan? **RZ:** eh…ahí tienes que preguntarle a R.S. **G:** vale, perfecto. Y bajo hileras, y bajo hileras? **RZ:** ah espérate, tu me preguntaste entre hileras. No entre hileras se corta. Sobre la hilera, se aplica herbicida. Y también a veces se corta. Hay lugares que no puede, en los cerros, toda esta parte que es cerro, las máquinas no llegan entonces ahí es manual. Y allá se hace corto y se aplica herbicida de forma manual pero…pero se hacen los dos un poco mix. Pero lo ideal sería tratar de no hacer nada con las hierbas. Y ahí hay que desarrollar algo. **G:** y…y usan labranza de suelo? **RZ:** poco. Ahora está labrado pero poco. Por varios motivos. Uno que con tanta lluvia nosotros no podemos meternos porque en la parte baja, es muy arcilloso se forma…es muy acumulador de agua entonces necesitas	**practices – Interraw and undervines / weeds** Use chemical herbicide undervine leave the grass grow interraw and maw it when needed Would like to have grass undervine and work mashing them but still lack technology Work with partial tillage when needed. But prefer leaving the grass grow to drain the water that is abundant in the lowland.

	algo que te ayude a drenar, y las hierbas en el fondo te ayudan en esta época. Por otra parte en esta época el problema del pasto no es muy grande porque tenemos los caballos y realmente comen harta hierba. Y la labranza en el fondo, yo creo que si te ayuda en lugares donde tienes problemas de agua. Y tu quieres acumular agua, acá hay agua, salvo en estas partes [muestra en el mapa] que son más de cerro, hay agua hasta el verano, no es un tema.	
14	**G:** ya, y de dónde llega el agua? **RZ:** de los cerros, escurre… **G:** por la lluvia **RZ:** si. Bueno ahora está lloviendo y esta se acumula, y en verano tenemos, tienes escurrimiento. De hecho esto que ves acá [muestra en el mapa], esto es como una vertiente que sale de por acá, y todo en verano, todo esto está lleno de agua. Bueno en primavera, en verano acá se seca, corre otro por ahí… ahora no es nuestra, no podemos sacarla, pero al final tenemos….	**ESS – water provision** Not explicitly mentioned: Water comes from the hills. Have water all year round
15	**G:** vale, y usan riego ustedes? **RZ:** si **G:** en todo el viñedo? **RZ:** todos los vinos usan riego, o sea estamos tratando de que los vinos de arriba sean más…que sean sin riego, y las viñas más antiguas casi no en esta parte [muestra en el mapa], casi no necesitan riego en verano porque, a parte que acumulan agua en el suelo, las raíces han llegado bien al fondo y no es tan seco. Pero la idea es tratar de…de llegar a no sin regar… **G:** de no regar ahí **RZ:** si, pero si se riega hoy **G:** y qué tipo de riego tienen? **RZ:** solo por goteo. **G:** por goteo. Y el agua del riego, de dónde lo sacan? **RZ:** viene en pozo que está como a 3 km de acá. **G:** y cómo llega? Limpia o tienen que pasarlo por un estanque? **RZ:** llega a varios estanques, de digamos de decantación. Pero es relativamente limpia no…a ver, que nosotros trasbordamos desde 3 km. Llega a un primer estanque que está acá y que se va distribuyendo digamos otros distintos estanques de acumulación. Algo de deposito se hace, pero tampoco es que decantemos mucho el agua, no se limpia con filtro. Si tu quieres salvarte de propiciar las semillas, pero es difícil que tenga semillas porque viene de un pozo a 100 m de profundidad, el agua. Entonces no puedo decirte… si te puede aportar dureza o todas estas cosas pero del lado de...hierbas semillas yo no	**practices – irrigation** irrigate all the vineyard with drip irrigation. Water comes from a groundwater well 3 kms away, clean. Irrigation is not so needed in the low-land where the soil accumulates a lot of water and the roots already reached the groundwater. Would like to have dry-farmed vines on the hillsides

	sé si…es pozo no lo hé analizado no sé si hay cruces con agua que viene de tan abajo.	
16	**G:** y esta agua lo vinculas de una cierta manera con el ecosistema natural? **RZ:** el agua? **G:** si, o sea esta agua de pozo. **RZ:** ….natural, natural no porque está a 3 km. Pero tampoco es que sea…es un agua de una napa digamos, de estas como…cómo le llaman? Ojos de aguas profundas, que de una cierta manera también llega de este lugar. Eh…lo ideal sería poder acumular el agua de…de la misma cuenca pero nosotros no tenemos los derechos sobre esta agua. En un momento nos propusimos hacer un tranque, pero averiguamos y legalmente no podemos hacerlo. Eh…yo creo que igual es parte del ecosistema. Porque es de acá no es que lo traigamos de otro valle a pesar de que está a 3 km, es bien local, viene de los cerros de acá, yo diría que….y es tan profundo el pozo que no sé si la intervención humana en estos lugares se…como digo no hemos hecho análisis no sé si a 100 m de profundidad o a 80 m de profundidad se pueda disolver lo que hacen los cultivos de este lugar. No lo tengo claro.	**RS irrigation – water provision** tried and design a system of stocking and using the water flowing in their field, but don't have the right to use it. The groundwater also comes from local precipitations filtrating from the hills.
17	**G:** y en termino de fertilización qué práctica..? **RZ:** fertilización totalmente…no, no totalmente. Mineral, gran parte, y hay una aplicación de compost. Nosotros hacemos compost, tenemos una cancha de compost acá [muestra en el mapa], este es una cancha de compost. **G:** vale. Y qué compostan? **RZ:** los orujos, los escobajos, más que nada eso. Eh…y se reintegra después en ciertas partes del viñedo. Ahora no alcanza a fertilizar todo entonces, se va aplicando en ciertos lugares pero en gran parte es fertilización mineral. **G:** y cómo eligen los lugares donde se va aplicando? **RZ:** las partes más desuniformes…porque tu tienes, ahí tienes esto es un cuartel [muestra en el mapa], cierto? En este cuartel, acá, que es el 3 debe hacer 12 ha, que es gigante. Pero este es muy des-uniforme en cuanto al vigor, o como están las plantas y también haciendo análisis de suelo tienen diferencia de suelo entonces uno va tratando de uniformizar aplicando compost en lugares más débiles. O lugares ponte tú que sientes que el suelo está más apretado aplicas compost. Entonces se va haciendo la aplicación en estos lugares que sentimos que necesitan o aireación, o más fertilización. Ahora no alcanza para todo. Y hoy en día lo estamos haciendo en los cuarteles de mejor calidad. Para tratar de cierta manera fertilizar lo menos posible en forma artificial.	**Practices – fertilization** Mainly mineral fertilization. Compost the winery residues and apply on the weakest sectors of the vineyards – reserved for high quality wines.

18	**G:** porque qué vinculo sienta que la fertilización artificial pueda tener con…con el suelo o con lo que dice usted? **RZ:** la fertilización artificial…ui…es mineral, la fertilización entonces…es una buena pregunta yo no sé cuanto afecta el s…en términos de…yo no sé cuanto podrá afectar ecosistemicamente la fertilización. Yo si siento el tratar de fertilizar es porque no hay un balance. No estoy en conocimiento de decir la, el hecho de fertilizar te rompe más el balance. A qué me refiero? Si tu tienes micorrhizas, tienes micro-organismos en el suelo te va a ayudar a fertilizar más. No sé si la fertilización, fertilizar te daña esto.	**RS Fertilization – soil fertility** ?? doesn't feel the sufficient knowledge to affirm that mineral fertilization impacts the soil life. Mycorhizes and micro-organisms participate to soil fertility
19	Pero si sé que ponte tú el uso de herbicida o el uso de estas practicas te destruye este balance.	**RS weed – soil fertility** Using herbicides destroys the life-balance of the soil
20	Por otro lado, tu todos los años le estás quitando nutrición a la viña al sacar uva. Si tu no lo repones, que nosotros tratamos de reponerlo pero no es suficiente, con la materia orgánica del compost, tienes que entregársela por otro lado. Ehh..yo no sé si la…no sé si la nutrición artificial es contaminante para el ecosistema…no sé pero si estoy seguro de que hay un daño en el ecosist…en el balance ecosistémico que hace que en el fondo tengas que aplicar nutrientes.	**RS fertilization – soil generation** when you harvest the grapes you quit organic matter that you have to replace. The compost is not enough to replace what you took. There is a disbalanced created by the viticulture that generates the need for external nutrients.
21	**G:** vale, perfecto. Y al nivel de…cuando hacen manejo de rendimiento, o manejo cultural o manejo en verde que dice usted…que hacen con los residuos? **RZ:** se dejan ahí mismo. **G:** ahí mismo. Se pican o…? **RZ:** mmm…no porque generalmente, a ver la poda se pica. La poda, la seca, se pica y se deja ahí mismo. Generalmente se deja ahí mismo, en otras partes a veces se sacan y se dejan en los caminos para mejorar los caminos. **G:** la estructura del camino. Ya.	**Practices – inter and undervines** Pruning residues are mostly chopped and left on the soil, sometime get it out to improve the structure of the ways Only do pruning and defoliation
22	**G:** y este campo está muy afectado por enfermedades y plagas? **RZ:** tenemos las mismas plagas que todo el mundo. Yo diría que de cierta manera como estamos aislados tenemos un poco menos de intensidad de algunas plagas, pero están las mismas el oïdio…no tenemos mildiu, esto en Chile es raro que encuentren mucho mildiu. Pero tenemos oïdio, tenemos botritis, tenemos… **G:** polilla?	**RS Landscape elements – biocontrol** indirect: Not very affected by pests because they are isolated

	RZ: la polilla, hay lovesia pero no mucho. Han encontrado pero la verdad es que daño por Lovesia no he visto. Hay pololo, mucho coleóptero, que hay muchos acá y esto es medio local, que ataca el carmenère. **G:** el carmenère está por acá si me acuerdo bien [mostrando el mapa]	
23	**RZ:** esto es Carmenère [mostrando el mapa, cuarteles centrales]. Y sabes lo que pasa**? Mira, esta zona [muestra el mapa] que es la que más me gusta a mi, está más silvestre, y donde menos intervención humana hay. Y acá es donde más micro-organismos tenemos. Y ahí es bueno y malo. Es donde más cuesta fermentar, y es donde más problemas de oïdio tenemos en estos sectores, pero por otro lado siento que es el lugar con más personalidad del campo, en aspecto de tipicidad de los vinos**. Entonces ahí es donde hay un tema ecosistemico fuerte que no hemos…bueno que tampoco mi intención es cambiarlo, pero…pero hay una riqueza microbiana mayor que esta parte que está más como…no muerta pero más inerta diría.	**ESS – NEW!** the area closest to the forest is the most "living" area: more micro-biodiversity, more fungi…but also more character in the wines!
24	**G:** y que hacen ustedes para luchar, o sea para evitar la expansión…demasiada de plagas y enfermedades? **RZ:** acá el trabajo no es orgánico y... Acá se aplica mucho azufre, que eso si es orgánico, o sea digamos de trabajo orgánico. A mi me carga el azufre, pero se aplica mucho el azufre y algunos productos sistémicos, químicos digamos. Si se trata siempre de…y creo que lo hemos cumplido por un tema de sustentabilidad, de aplicar productos con etiqueta verde, jamás con…con otro tipo de etiqueta. Generalmente, todo lo que es arañita tratamos de hacerlo con aceites y no con pesticidas muy fuertes. **G:** aceites minerales? **RZ:** si. Pero más allá de eso no…no hemos hecho mucho.	**Practices – P& D** Sulphur against oïdio, systemic pesticides Mineral oils against Brevipapu Chilensis
25	Y por esto ver el estudio de las levaduras es interesante, y de hecho lo estamos haciendo en este sector con el Carmenère, para saber que es lo que tenemos ahí. **G:** si de hecho fuimos por allá a cosechar en abril. **RZ:** este año fue bien difícil…	**ESS – fermentation microorg** Are part of the research project of VCCB to study the presence of fermentation microorganism on the grapes
26	**G:** si fue particular, fue particular. Y la cosecha cómo se maneja acá? **RZ:** manual y mecánica. Diría que la parte manual…mira la parte manual, porque también hay una división de cosecha por calidad. Entonces acá [muestra en el mapa], tu tienes estos cuarteles que son…lo plano es lo más fácil de cosechar de forma mecánica, pero hay por ejemplo este que es de calidad alta se cosecha manual, este	**Practices – harvest** Manual for high quality, high slope and high density plantations and mechanical for less qualitative vineyards would like to have everything manual to preserve the plants but don't have

	también, este también es manual, esto es mecánico, esto es manual porque es alta densidad pero se va a eliminar la alta densidad entonces va a ser mecánico. Esto es mecánico mecánico, mecánico…esto es manual, manual, a pesar de que podría ser mecánico, entonces ahí hay una mezcla. Por ejemplo esta zona de acá, es una zona manual porque ahí ya no llega la máquina, ahí también. Manual por la pendiente, manual por la pendiente. **G:** y siente que el tipo de cosecha tiene una interacción con los servicios que le entrega… **RZ:** seguro que si. Seguro. La máquina arrasa con todo, no se preocupa de distinguir una de otra cosa. El problema es que no lo puedes hacer todo manual…no hay mano de obra, tendrías que pagar unas…diez veces lo que tu pagas no hay gente para poder llegar en los tiempos…	the means nor the labour force to do so
27	**G:** la gente que si llega a trabajar con ustedes son locales? **RZ:** si, son todos lugareños. **G:** y que tal la relación con ellos? Cómo se llevan..? **RZ:** yo diría que buena. Bueno, ha sido…depende mucho de la jefatura pero en general tenemos una buena relación. Es un tema que hemos tratado de trabajar porque anteriormente Caliterra no tenía muy buena fama cuando llegué el 2011, la gente no quería venir a trabajar, y se ha hecho un esfuerzo tanto de clima laboral como monetario. Monetario siempre hay competencia, no es fácil pero al menos el clima creo que lo hemos mejorado harto y hay gente que trabaja acá no solo por el dinero sino que porque le gusta estar acá también. Aparte que el lugar es muy lindo, pero tiene que haber un trato especial también sino…y hemos tratado, y esto es parte del tema sustentable también, hemos tratado de involucrar a la comunidad en todo… el tema entre comilla ecológico que hemos hecho. El tema de las aves, el tema del reciclaje que lo vamos a retomar este año, tratar de implementar el reciclaje y incentivar a que cada uno traiga de su casa reciclaje…la comunidad tratar de compartir con colegio, con todo el cuento externo. El tema social en este sentido ha sido fuerte. Hemos participado y casi quedado en un comité ambiental con la comuna, en el cual participamos, hacemos actividades, caminatas, tratamos de enseñar a la comunidad lo que es el tema ecológico.	**practices - social** overall good RS with the locals. Was hard to convince people to come and work in the vineyard but did an effort and manage motivate Try and involve the community in the sustainable-practices they are developing: sensibilization to stop hunting birds, prohibition of the game on the vineyard diverse activities, walks in the vineyard with sensibilization to the environmental issues
28	**G:** dentro del viñedo se hacen las caminatas? **RZ:** dentro y afuera en el fondo, tratando de motivar el cuidado. Se prohibió la casa, se empezó a cuidar más los animales nativos…se han encontrado cosas cholas en el lugar. Que la peor plaga que tenemos es el conejo. **G:** mmmh…y cómo lo manejan, el conejo?	**practices – conservation** Restricted access to the vineyard to prevent from hunting on the hills have less rabbits since they forbid the game than before when they were

	RZ: hoy en día no estamos haciendo nada. Y sorprendentemente hay menos conejos. Porque antes dejábamos que casaran, ya sea con armas o con…con trampas. Y nos dimos cuenta que no...por lo menos yo nunca vi una disminución de los conejos. Entonces el año 2013 o 14 no me acuerdo, prohibimos la caza. Por esto la guardia en la entrada antes no había guardia acá. Y no se puede entrar acá salvo de con un permiso muy especial y que se sepa que no van a hacer daño al ecosistema. Porque que es lo que hacían los cazadores, mataban todo. Y había una disminución de los zorros, una disminución de los quiques. Disparaban me imagino a los pájaros entonces hoy en día tenemos mucho más depredadores que han ido controlando los conejos. Lo que tenemos en realidad como plaga son las liebres porque no tenemos muchos depredadores para las liebres. Que esto también es exógeno, la liebre también fue introducida en Chile. Pero los conejos se ven cada vez menos. **G:** y me habló de un proyecto con las aves, que hay ahí? **RZ:** lo que pasa es que, bueno ahora estamos llenos de aves depredadoras. Nosotros no sabíamos esto y el año 2013 hicimos una…hicimos un levantamiento de aves. Que en el fondo, Caliterra naturalmente siempre ha estado lleno de aves y se considera un corredor…un corredor de aves migratorias. Entonces siempre estamos llenos de aves. Hicimos un estudio de la cantidad y la variedad de aves que teníamos, y en este estudio se rojo que teníamos muchas aves rapaces. Aguilas, peuco, aguiluchos, falcones, una cantidad de la familia de los búhos importante. Entonces lo que hicimos fue poner dentro del viñedo, el tipo este que nos hizo el estudio, trató de seguir las rutas de caza digamos de las aves, y puso en el viñedo algunas casas, anideras o plataformas para tratar de acerca a las aves al viñedo. Y para que en el fondo fueran a cazar dentro del viñedo. Y la verdad es que hemos visto que las aves cada vez están más cerca, por otro lado hemos hecho un trabajo con la comunidad, con la gente que trabaja acá que no le tengan miedo ni odio porque la gente acá odia las aves rapaces porque les comen las gallinas, les comen los conejos propios, entonces las mata. Entonces les hemos enseñado que no, que nos ayudan y que…y la gente ahora ya les tiene cariño a las aves. Y tenemos muchos búhos que caza, tanto ratones como conejos. Y este levantamiento se hizo, y se ha visto una disminución. Ahora también la disminución puede ser ayudado por las aves rapaces pero también ha	killing them: foxes and Quiques came back Participated to a study: the Vineyard is inside of a migration corridor for birds, installed niches for the birds and tought to people not to kill them **ESS – biocontrol** foxes and Quiques control the rabbits

	muy fuertemente ayudado el aumento de quiques. Sabes lo que es un quique? **G:** si, es como una nutria…pero nativa **RZ:** como un…si, estamos llenos de quiques. De hecho se ven, se ven.. **G:** y de visón no? **RZ:** no, pero es exógeno el visón. **G:** si, si. Pero como se roban el niche de los quiques….o sea no directamente pero como se alimentan de las mismas fuentes, y el visón es… **RZ:** no. de hecho hemos exportado quiques, a otras viñas que han venido y nos han pedido quiques. **G:** y funcionó? Se instalaron? **RZ:** si, si de hecho acá abajo, hay una familia de estas. **G:** esto es por la misma vertiente que anda bajando o no? **RZ:** yo creo que puede ser pero si uno le pregunta a cualquier persona del campo te va a decir "no, yo no veo muchos conejos pero lo que si vemos todos los días son quiques".	
29	**G:** genial, buenísimo. Últimas preguntas, me habló de ganado que tiene para el manejo… **RZ:** ganado ganado no…bueno no lo manejamos como ganado pero son rumiantes. Tenemos caballos salvajes que durante el verano están comiéndose el pasto en los cerros, y en como una forma de prevención de los incendios, para que mantengan la maleza baja y no se…y realmente son efectivos yo pensé que era…en un momento pensé que era más marketing, pero recorriendo los cerros y ponte tú si un o se para en el deslinde entre la propiedad nuestra, los cerros nuestros y los cerros del vecino la diferencia entre el pasto del uno y otro es gigante. Y en invierno se están comiendo las malezas digamos de..de acá del viñedo mismo. Están caminando en el viñedo, y tenemos alpaca pero esto es decorativo y esto es todo el año en el viñedo. **G:** y pastorean entre las… **RZ:** pastorean entre las hileras y… **G:** y no le hacen nada cuando está verde? **RZ:** no, no, sorpresivamente las alpacas no son muy agresivas. Y no comen mucho no hacen nada. A veces se nos meten por…los caballos son muy agresivos, por esto tenemos todo cercado y deslindado, y a veces se nos meten por acá por los vecinos unas cabras, que esto si que hay que sacarlas al tiro o se comen todo, o vacas que son de los vecinos. **G:** bueno. Y esto lo vinculas de una cierta manera con el ecosistema la presencia de ganado…	**practices – cattle** wild horses and alpacas: use them as prevention against fires: eat the dry grass on the hills in the summer. sometimes have problem with the goats and the cows of the neighbours that get into the vineyards and eat everything

	RZ: no. Se introdujo y hoy en día se mantiene sobre todo por un tema de marketing que…de una cierta manera hemos visto el beneficio en el tema de los incendios nosotros no hemos tenido incendios…yo nunca he sabido de un incendio acá, y lo único que hemos tenido…digamos el xxxxx más que un incendio. Pero hemos tenido en el viñedo incendios, causados por el hombre y por lo seco que son algunos años, porque se hacen chispas lo que sea, y yo creo que es importante mantener los cerros protegidos porque se nos llega a quemar el ecosistema que tenemos acá y es un daños natural importante entonces…pero si hay un provecho en términos de que nos ayudan en dos facetas importantes pero no es nativo. Pero le estamos sacando provecho si. Las alpacas yo diría que es más decorativo. Pero los caballos si.	
30	**G:** perfecto. Y última pregunta ustedes piensan en expandir la viña acá o lo han hecho recién o? **RZ:** no, la viña está bien, establecida. Hay ganas de ver si es que en el futuro, podemos plantar esto que ya está arrancado de hecho si te fijas esto todo está blanco. Ya esto son…esto está raspado y se sacaron los arboles el año no sé…yo desde que llegué que está así. Y no se ha plantado, se está esperando a ver si se planta ahí, o tal vez acá atrás de la bodega un pequeño pedazo pero así como una gran parte no.	**practices – land use change** have a piece of land that they deforested years ago (before he arrived) and that's not planted yet. Maybe they plant there
31	**G:** y usted me mencionó un trabajo que está haciendo con corredores ecológicos? **RZ:** con los corredores biológicos? Esto ya los tenemos, no sé si 12 o 14 corredores ecológicos aquí en el viñedo. No se si se ven pero [muestra en el mapa] acá tienes uno. Acá tienes otro…acá tienes otro acá, tienes otro acá y hay varios más que se han ido forman..haciendo. **G:** cuando usted me muestra algo es porque plantaron algo…? **RZ:** si, se pusieron…y ahí yo no estoy tan de acuerdo se pusieron variedades exógenas. Que…porque hay un corredor ecológico que es como la madre de todo que es la parte de acá. Donde se hizo un estudio con varias…con la universidad de Lincoln en Nueva Zelanda y la universidad de Talca de Chile y se escogieron algunas variedades que se supone atraían enemigos naturales o lo mantenían. Y también al frente tenemos uno que es corredor biológico de plantas nativas. Pero el que ha replicado es el de modelo de plantas exógenas lo cual no sé si es muy bueno pero… **G:** y usted ve una diferencia entre las especies que se observan entre el nativo y el exógeno?	**practices – landscape elements** planted and natural ecological corridors in the vineyards: planted exotic species supposed to attract more the natural enemies **Actors** project of ecological corridors realized in partnership with Lincoln University of New Zealand and University of Talca

	RZ: si si. De hecho en las plantas nativas no se ve mucho color, es más verde que otra cosa. En el exógeno es una fiesta de…en primavera está lleno de colores. Y atraen mucho más bichos visibles, se ven muchas moscas volando y otras no tanto. Pero igual creo que quizás exógeno no se si es bueno.	
32	**G:** y ha tenido impacto la presencia de estos corredores en la viña? O sea… **RZ:** hace tiempo que no se hace un levantamiento pero en un momento se hizo un levantamiento, y había una gran población de enemigos naturales…cuando teníamos solo estos dos, habían muchos enemigos naturales en esta zona. Pero incluso se ven enemigos naturales en otras zonas también. La idea es mantener esto, y por esto hemos ampliado la...digamos las distintas áreas donde hay corredores biológicos y todos los corredores biológicos tienen que estar ligados a corredores biológicos naturales que son las quebradas donde está lleno de arboles, de arbustos y de plantas. Si te fijas que acá uno tiene harto quebradas que mantuvieron la vegetación, los arboles, en algunas islas de arboles puntuales que están entremedio del viñedo pero que en general hay hartos bordes, digamos calles de…vegetales.	**RS landscape elements – biocontrol** noticed more concentration of natural enemies in the ecological corridors Natural enemies also present in the native ecosystem, now the objective is to preserve and enhance native species in the ecological corridors
33	**G:** si, perfecto. Otra práctica que usted le gustaría mencionar? **RZ:** que hacemos o que nos gustaría hacer? **G:** que no hemos mencionado…ambos que hacen o que les gustaría hacer **RZ**: que hacemos?... te mencioné lo de los corredores, te mencioné, bueno tu me hablaste de los cultivos anteriores que es algo que a mi me fascina…los caballos, las aguilas, no, yo creo…para mi si es importante en el futuro tratar de trabajar de buena manera las malezas y tratar de no…lo ideal para mi es no usar herbicida. **G:** porque actualmente tienes que aplicar varias veces al año? **RZ:** se aplica dos o tres veces si. Me gustaría mantener un ecosistema más, más limpio abajo en el suelo con las raíces, porque al final el herbicida te contamina mucho. Esto me gustaría lograr pronto, pero estamos en esto.	**PP – feelings and opinion** would like to find a way to stop applying herbicides on the vineraws.
34	**G:** perfecto. Última pregunta…pen-última pregunta: certificaciones para el campo tienen? **RZ:** tenemos la de sustentabilidad. **G:** viene de un organismo especial? **RZ:** si, o sea nos viene a certificar IMO, nosotros, pero es un código que lo desarrolló…bueno de hecho lo desarrollo Caliterra, y se lo regaló a Wines of Chile, y	**MP – certification** sustainability label from Wines of Chile certified IMO for sustainability

	después Wines of Chile lo hizo nacional digamos y a través de certificadora externa según el código se certifica sustentable. Ahora el código Caliterra lo hicimos en función a un código ya existente en Nueva Zelandia, en…Canadá y Alemania. Entonces no es algo inventado sino que, yo diría que la cosa que más falta en este código es el tema de las malezas. Que esto es porque en el fondo Caliterra lo exigía pero Wines of Chile lo liberó un poco porque sino no se hubiese certificado nadie.	
35	**G:** mmmh perfecto. Y última pregunta: usted participó en el taller del proyecto VCCB, o sea del proyecto de la Olga del programa Vino Cambio Climático y Biodiversidad? **RZ:** cuál taller? **G:** un taller que organizan para las viñas participantes, sobre la biodiversidad, las flores nativas… **RZ:** que vienen acá? **G:** si **RZ:** si, si estuvo. Estuvo uno bueno eso, corto pero bueno.	**VCCB – workshop** Yes
36	Un buen incentivo. Yo creo que fue muy bueno y tuvo un buen impacto en la gente que participó. Es una forma lúdica también de entender lo que hace el ecosistema, y…y se comentó, el impacto fue durante un tiempo que se comentaba mucho el tema del ecosistema, pero hay que ir reforzando, nosotros fuimos internamente también ahí recordándolo y tener…como recordar todo lo que hace este proceso. **G:** perfecto. Y lo hacen de manera…especial? **RZ:** tratamos de hacer reuniones, este año no ha sido tan fácil pero tratamos de mantener reuniones con respecto al tema de la sustentabilidad mensual, y hay que renovarla ahora con el cambio de jefatura, la llegada de R., se fue un enólogo llegó otro entonces, ahora, después ahora que terminó la vendimia una de las cosas que quiero retomar es esto. Y las personas también hay que tratar de ver alguno incentivo monetario con el tema sustentable y todo… **G:** mmmh, buenísimo. Perfecto, merci beaucoup! **RZ:** derien!	**VCCB** consequence of the VCCB workshop: started to gather and reflect about sustainability issues and actions within the vineyards would like to implement a monetary incentive system

APPENDIX IV : Code-book used to analyse the interviews

1. First and second levels of codification

Concept	description
Practices - Yield and canopy	control of the vine's vigor and grape yield
Practices - Interrow soil cover	soil cover management: baresoil / permanent or temporary use of vegetal cover (natural or covercrops)
practices - interrow soil labour	tillage / no tillage, decompaction practices
Practices - Harvest	harvesting methods
Practices - Fertilization	Management of vines' nutrition
Practices - Undervines / Weeds	Management of the weeds and soil undervines.
Practices - Pests and diseases (P&D)	medthods of control of invasive and harming species in the vineyards
Practices - Irrigation	Methods captation of water and dispertion into the vineyards for the growth of the vides
Practices - Land conversion	Decision to cut native ecosystem in order to install new vineyards
Practices - Landscape elements	management of non cropped species within and around the vineyards (native or / and introduced)
Practices - Cattle	Control or use of domesticated animals within the vineyards
Practices - Other	Other practice not described in the inital code
practices - social	issues and tasks concerning local community and workers
Practices - conservation	Policies and practices to enhance native biodiversity
Personal position - Ecosystem Service (ESS) ddefinition	Benefit vineyards get from surrounding natural ecosystems
ESS - climate regulation	Influence of ecosystems on local and global climate through land-cover and biologically-mediated processes
ESS - biocontrol	use of living beings to control pests and deseases
ESS - water quality	Role of forests in water infiltration and purification
ESS - water provision	Role of forests and montains in regulating the gradual release of water
ESS - Fermentation microorganisms	Role of forests in hosting and releasing key-yeasts for wine-making process
ESS - soil fertility	role of natural processes in decomposition of organic matter and provision of plant-available forms of nutrients
ESS - soil generation	Role of natural processes in soil formation and regeneration
ESS - cultural identity	identification of people to the vineyards and mediterranean native landscapes, involvment of locals in the vineyards
ESS - recreational	use of the landscape diversity for tourism / leisure acitivities
ESS - esthetic	Valoration of the beauty of the vineyards - native mediterranean landscape
RS Harvest - soil generation	Impact of the use of the harvesting machinery on the soil structure and generation processes

RS Harvest - Cultural ID	Impact of the replacement of humans by machines / employment of extra-staff and organization of events around the harvest
RS Fertilization - soil gen	Use of the natural processes generating soil life in order to provide vides with nutrients / impact of the soil labour and use of inorganic fertilizers on soil structure and generation processes
RS fertilization - soil fertility	Use of organic matter to fertilize soil / impact of inorganic fertilizers and soil labour on soil organic matter content
RS fertilization - water quality	Impact of external nutrients input on infiltrated water
RS Cattle - soil fertility	use of animals to bring organic matter / impact of animals on soil organic matter content
RS cattle - biocontrol	Use of animals to control pests
RS cattle - soil generation	impact of animals on soil structure and generation processes, protection of native ecosystems from erosion due to overgrazing
RS cattle - recreational	Use of animals as a tourism / personnal acttraction
RS yield and canopy - soil fertility	Use of prunning residues to increase soil organic matter content
RS yield and canopy - biocontrol	Use of prunning and defoliation to avoid pests and deseases' spread
RS inter and undervine - soil gen	use of covercrops to improve soil structure and enhance soil generation processes / impact of machinery use on soil structure
RS inter and undervine - soil fertility	Use of covercrops to increase soil organic matter content
RS inter and undervine - biocontrol	Use of covercrops or pastures interraws to enhance circulation of natural enemies or generate pests repulsion
RS weed management - biocontrol	impact of weeding methods on natural biodiversity
RS weed management - soil generation	impact of weeding methods on soil structure and generation processes
RS weed management - soil fertility	impact of weeding methods on soil organic matter content
RS P&D - soil fertility	impact of the pests and desease control methods on soil organic matter content and soil life
RS P&D - fermentation microorg	impact of P&D control methods on te presence of yeasts on the grape
RS P&D - water quality	Recognition of possible contamination of water by chemical compounds
RS P&D - biocontrol	use of exotic or native species to control P&D
RS Irrigation - Soil fertility	enhancement of soil organic matter content through irrigation
RS irrigation - water provision	recognition of the natural origin of the available water
RS irrigation - soil generation	
RS land conversion - climate regulation	impact of land-use change on the temperature and humidity conditions
RS land conversion - esthetics	Impact of the land-use change on the beauty of the landscape
RS landscape elements - biocontrol	use of ecological corridors as habitat for biocontrol agents / recognition of lack of natural areas inside the vineyards

RS landscape elements - fermentation microorg	Recognition of the presence of more yeasts on the vides closer to the native ecosystem
RS landscape elements - cultural ID	Local activities based on the native ecosystem present within the vineyard
RS landscape elements - recreational	Valoration of the natural areas within the vineyards for personal and tourism uses
RS landscape elements - esthetics	Valoration of the beauty of the vineyards - native mediterranean landscape for personal well being
Management paradigm - conventional	explicit mention of the viticulturist
Management paradigm - organic	explicit mention of the viticulturist
Management paradigm - integrated	explicit mention of the viticulturist
Management paradigm - biodynamic	explicit mention of the viticulturist
Management paradigm - certifications	Impact of the certfications on the vineyards' management
Management paradigm - organic transition	Present or past stage of organic transition period
Management paradigm - biodynamic transition	Present or past stage of biodynamic transition period
PP - position in the firm	Current position and responsibilities of the interviewee
PP- history and background	field of studies and previous experiences
PP - feelings and opinion	expression of personal point of view on a topic
Actors	Actors surrounding the viticulturist and influencing in the vineyards' management
VCCB	opinion and mention of the VCCB impact on the viticulturist

2. Third level of codification

3. Ecosystem Services

Direct recognition	the interviewee names the ES as a service he gets from nature
Indirect recognition	the interviewee establishes an indirect link with the natural ecosystem while speaking about his practices, or admits its existence when asked

definition_ES	
Nature_to_viticulture	defines ES as benefits from natural ecosystems to the vineyards agroecosystems
Viticulture_to_Nature	define ES as the result of their environmental initiatives within the vineyard on the surrounding natural ecosystems
Interaction_Viticulture_Nature	define ES as an interaction between the vineyard agroecosystem and the surrounding ecosystems
None	No intuitive definition of the ES concept

Interrow_soil_labour	
Tillage	Soil labour over 20cm interrows
Superficial_tillage_every_other_row	Soil labour under 20 cm interrows
No_Tillage	No soil labour except mowing
Decompaction	deep soil work without ploughing to break the compaction belt at certain depth (50cm - 1m50)

Interrow_soil_cover	
Half_baresoil_half_covercrop	half of the interrows are sown with covercrops while the other half is tilled superficially
Permanent_Covercrops	Covercrops are sown every year and left untill they dry or cut but no soil work is made to incorporate them
Half_baresoil_half_natural_flora	half of the interrows are left with natural grass while the other half is tilled superficially
Natural_flora	all the interrows are left with natural flora. mowing when needed

Undervine_weeds	
Mechanical	superficial soil work with machines or human labour to incorporate the weeds
chemical_monitoring	herbicide application localized to weed focus
chemical_systematic	herbicide application on al the vinerows
chemical_syst_and_monitoring	herbicide application on al the vinerows, supplementary application to focus with resistant weeds
Landscape_Elements	
Inter_plots	Plantations of non-cropped species around the vines plots
Gulches_hills	allow the natural vegetation to grow on the gulches and hillsides crossing and surrounding the vineyard
Within_and_around_vineyards	do both inter-plots and natural relieve plantations
Conservation	use native vegetal non-cropped species
Exotic	use exotic vegetal non-cropped species
Exotic_and_conservation	use a mix of native and exotic non-cropped species

Fertilization	
Organic	Apply mere organic compounds or derivates to fertilize
Mineral	apply mere mineral compounds to fertilize
Organic>mineral	mix of organic and mineral fertilizers : application of mineral fertilizers is based on the lacks left after organic fertilization
Mineral>organic	mix of oragnic and mineral fertilizers : application of organic fertilizers is a « bonus » to a mineral fertilization program
Compost from winery	Spread the composted winery's residues on the vinerows
Incorporation of prunning residues	Cropping residues are chopped and left as mulch on the interrow or integrated in the upper soil layer
Urea	use of Urea as N-fertilizer
Liquid fertilizers	Use of liquid forms of NPK fertilizers
Guanos	Use of composted cow or chicken dung on the vinerows
biodynamic preparations	use of self-prepared mixes of plants following a special process proper to biodynamic viticulture
covercrops	consider covercrops as green manure / use special N-fixing covercrops
mulch	Mention the prunning residues as mulch or apply straws on the vinerows
Bio-stimulators (algeae, humic acids, bacteria inoculum)	Use of concentrated algea or humus extract or inoculation of soil-microorganism to stimulate soil life
organic fertilizers	use of external organic compounds

Pests_and_diseases	
biocontrol_agents_liberations	induced biocontrol with liberations of bought natural enemies on pests' spots
Conservation_biocontrol	use of the natural enemies present on and around the vineyard to control the pests
Organic pesticides	application of pesticides and fungicides authorized by the organic certification conditions
Synthetic pesticides	application of pesticides and fungicides derivated from synthetic products
Canopy_management	management of the canopy aeration to control humidity of the grape cluster and decrease fungal pressure
Monitoring	regular field observation to detect pests and diseases' spreading spots and natural enemies' presence
Sulphur	applications of sulphur to control powedry mildew

Yield_and_canopy	
Integration_pruning_residues	integration of the pruning residues to the soi, through soil work or mulching
Conditional_management	management of the canopy aeration to control humidity of the grape cluster and decrease fungal pressure

Harvest	
Manual	100% manual harvest
Mechanical	100% mechanical harvest
Mechanical_and_manual	harvest partially manual and mechanical
opinion	viticulturist's opinion on the differences between manual and mechanical harvest

Irrigation	
Canal	irrigation water comes from a canal
Groundwater_well	irrigation water comes from a deep well extraction
Canal_or_groundwater_well	several fields under responsability with different sources of water
Canal_and_groundwater_well	one field receives water from both canal and deep-weel extraction

Land_conversion	
Not_Mentioned	Topic didn't come during the interview (not experiences nor in project)
On_native_Ecosystem	conversion of native Mediterranean forest or / and scrublands
On_exotic_or_degraded_Ecosystem	conversion of former agricultural or bare land

Cattle	
Winter_weeding-summer_hills	Animals are grazing on the vineyards in the winter and on the hillsides in the summer
Winter_weeding_summer_grassland	Animals are grazing on the vineyards in the winter and on pastures within the vineyards' properties in the summer
winter_weeding_summer_out	Animals are grazing on the vineyards in the winter and in the Andes in the summer
yearround_hills_fire_grazing	Animals are grazing on the hillsides around the vineyard all year round
Biocontrol	use of animals to control pests
Leisure	use of animals for touristic activities and esthetic
Not_accepted	Animals refused on the vineyard, protection against hunting and grazing
Biodynamic_preparations	use of animals to elaborate the biodynamic preparations

History_and_background	
Ingeneer	University formation as an agronomy ingeneer
œnologist (ingeneer)	university formation as an agronomy ingeneer with specialization in eonology
Technician	tehcnical formation in viticulture and horticulture techniques
other	Other background, experiential formation
Professional_background	professional experiences previous to the current job

Position_in_the_firm	
Vineyards_information	informations about the vineyard
Agricultural_manager	main responsible of the viticultural management in the firm
Chief_œnologist	main reponsible for the wine-making activities in the firm
Sector_viticulturist	Assistant of the agricultural manager, second main responsible of the viticultural management for part of the firm's vineyards
Field_administrator	Viticulturist of one of the firm's vineyard
other	other responsibility not described in this code

APPENDIX V: detailed literature review about the ES and their interactions with viticulture practices

Biocontrol

The ES of biocontrol is by far the most well-known of the numerous ES provided to the vineyard: it is mentioned in 14 out of the 30 papers studied in this review. The Biocontrol ES is defined as the regulation of the plant health conditions through naturally happening or human induced ecological processes involving living organisms. In the context of viticulture, naturally occurring biocontrol is linked to following ecological processes:

- The presence of a high biodiversity at the plot and vineyards' scales ensures a greater ecological stability of the agroecosystem. Indeed, having a wider diversity of species complying with similar ecological function, in this case the regulation of pests by parasitoid, insectivorous natural enemies or inhibitors of the pathogenic germs for the vines, enables to decrease the probability of a major pest expansion and thus decreases phytosanitary costs (Castañeda et al., 2015; Orre-Gordon et al., 2013; Projet Life + Biodivine et al., n.d.; Altieri and Nicholls, 2002).
- At the scale of soil, some microorganisms may ensure a key role in reinforcing plants' health and resistance against diseases and pests. Namely, Whitelaw-Weckert et al. (2007) underlined the possible role of cellulolytic bacteria in suppressing the vine's root fungal diseases, while Trouvelot et al. (2015) presented the property of disease's resistance through the secretion of exudates around the roots by the symbiosis between the vine and some arbuscular mycorrhiza fungi species. Nevertheless, further research efforts need to be done in order to better understand the complexity of the interactions at the soil level (Salomé et al., 2015).
- At the vineyards and landscape scale, Jedlicka et al. studied the role of native avian species in the biocontrol of insects pests within Californian vineyards, proving that the presence of some key insectivorous species generated a dramatic decrease in insect pests' abundance while regulated the presence of other opportunists avian species that may eat the grapes (2011). They thus opened again a research topic that had been abandoned by the north American researchers in 1940.

These ecological processes are sometimes being considered as part of the pests and diseases' management by the viticulturists who choose to integrate it through different methods:

- The term “Conservation biocontrol” defines the enhancement of local spontaneous biodiversity including species involved in the control of the vines’ pests and diseases. It is based on the regular monitoring of both pests and natural enemies. Conservation biocontrol can be enhanced through the integration of non-productive vegetal species as habitat for the natural enemies within the vineyards, called habitat modification (Orre-Gordon et al., 2013). Habitat modifications may include “exotic” or native species attracting key natural enemies (Danne et al., 2010, Tompkins, 2012).
- Biocontrol may also be induced by direct interventions of the viticulturist, through regular liberations of natural enemies’ (Pino Torres, 2013); the use of sexual disturbance signals or Herbivore Induced Plant Volatiles (Orre-Gordon et al., 2013); or the inoculation of biological control agents, like Trichoderma or precise mycorrhiza-fungi with different effects according to the edaphic and climatic conditions.

The enhancement of Biocontrol on the vineyards results in the emergence of an equilibrium generating consistent economical savings in phytosanitary costs on the medium to long run (Sandhu et al., 2016).

The natural occurring of Biocontrol may be influenced by following practices:

- *Landscape elements management:* The enhancement of wild biodiversity at landscape scale, through the introduction of natural ecological corridors within and around the vineyards or the implementation of concrete conservation practices such as installing perches or nesting boxes for the birds dramatically increases the species richness of the vineyards agroecosystem, thus generating an equilibrium between pests and natural enemies’ populations (Caprio et al., 2015; Castañeda et al., 2015; Jedlicka et al., 2011; Orre-Gordon et al., 2013; Pino Torres, 2013; Sandhu et al., 2016; Steel et al., 2017; Tompkins et al., 2012).
- *Interrows and canopy management*: Increasing the structural complexity of the vineyards’ agroecosystems at field scale, through diversification of the cropped species on the vineyards or constant and high grass cover in the inter-rows and increased leaf cover of the vines, enhances the diversity within functional guilds of natural enemies of the vines’ pests (Altieri and Nicholls, 2002; Caprio et al., 2015). At the vine scale, the control of the humidity conditions within the canopy through precise pruning ensures constant aeration and sufficient sun exposure, hence dramatically slowing the

development of fungal diseases on the vine and grape clusters (Altieri and Nicholls, 2002).

- *Cover crops:* Studies from Australia and New Zealand showed that the use of native cover crops in the inter-rows and on the vine-rows enhances native natural enemies (Danne et al., 2010; Tompkins et al., 2012). Using flowering cover crops in the inter-row during the summer, may they be native or introduced, also dramatically increases attraction for natural enemies (Sandhu et al., 2016; Tompkins, 2010). At the soil scale, the incorporation of vegetal organic matter through regular mowing of the vegetal cover increases the activity of cellulolytic bacteria that may play a key role in the suppression of fungal root diseases of the vines (Whitelaw-Weckert et al., 2007).
- *Fertilization:* The use of mulch as fertilization methods was shown to hinder the sporulation process of the fungus Botrytis cinerea, responsible for the grey mould on grape clusters, decreasing the conidiophore coverage on vines' debris of 66 to 95% (Orre-Gordon et al., 2013; Sandhu et al., 2016).

Soil generation and fertility

The soil generation Ecosystem Service encompasses the ecological processes resulting in the formation and conservation of a soil structure and physical properties. It enables the good development of plants' roots and the easy infiltration of water, thus preventing erosion. The soil Fertility ES refers to the regulation of soil nutrients' cycling through biotic and abiotic processes. Tightly linked to soil life and organic matter content, it determines the availability of nutrients for the plants. If they correspond to two distinct definitions, these two ES are the consequences of intertwined ecological processes that may sometimes be difficult to differentiate (Salomé et al., 2015). The soil generation and fertility conditions determine the way vine's root will penetrate and explore the soil in the search for water and nutrients (Castañeda et al., 2015; Lamastra et al., 2010; Pino Torres, 2013; Priori et al., 2015; Rochard, 2014; Salomé et al., 2015; Tompkins, 2010; Tompkins et al., 2012; Trouvelot et al., 2015), thus constituting an important part of the Terroir of each vineyard (Etcheverry, 2014). Despite the lack of understanding of the highly complex soil ecological processes (Salomé et al., 2015), interactions of the soil generation and fertility ES were already found with following viticulture practices:

- *Fertilization:* the application of agroecological principles at the field scale invites to consider the fertilization of an agroecosystem as a way to enhance natural processes

through provision of organic matter and stewardship of soil life instead of substituting them with mineral, directly available nutrients provision (Pino Torres, 2013) Thus, application of organic fertilization through compost, guanos, mulches and nitrogen-fixing cover crops enhances soil microbial activity, resulting in an improved structure and increased organic matter content (Lamastra et al., 2010; Salomé et al., 2015). Using mineral fertilizers inhibits soil life, thus slowing the soil generation and fertility processes. In particular, urea kills soil fungal life, while some fungal activity such as arbuscular mycorrhiza constitutes a key asset for vine growth in term of soil structure, nutrients capitation and diseases' resistance (Trouvelot et al., 2015).

- *Soil cover:* sawing cover crops on the inter-rows maintains good soil structure and aeration, thus preventing compaction and erosion. Moreover, the incorporation of the organic matter generated by the cover crops or the natural weeds growth increases the soil organic matter content, thereby boosting microbial activity and enhancing fertility on the long run (Etcheverry, 2014; Lamastra et al., 2010; Pino Torres, 2013; Salomé et al., 2015; Tompkins et al., 2012; Whitelaw-Weckert et al., 2007). It is even possible to use selected cover crops species with Nitrogen-fixing properties in order to intentionally increase soil nitrogen content (Pino Torres, 2013). Finally, in the non-planted areas, reforestation with native species enables to maintain good soil structure while preventing erosion (Tompkins, 2010)
- *Soil labour:* the practice of tillage destroys the soil structure and modifies soil microbial activity, resulting in immediate nutrient liberation but also in major decrease of soil carbon-content (Brunori et al., 2016; Salomé et al., 2015).
- *Weeding:* the use of herbicides on the vine-rows modifies the soil microbial activity and thus the soil generation and fertility processes. While some studies affirm the negative impact of herbicides on soil life, other studies showed contradictory results, proving that a long term use of glyphosate didn't generate a consequent decrease of soil microbial activity(Tompkins et al., 2012; Whitelaw-Weckert et al., 2007). Nevertheless, using herbicides induces leaving the soil bare at least part of the year and thus increases soil exposure to erosion and compaction. A study from New-Zealand proposed some native weed species as a good solution for under-vine soil cover for their low water need and fast development capacity in their native soils, thus offering a good substitute to herbicides on the vine-rows (Tompkins, 2010).

- *Irrigation:* water availability is a key factor of nutrient circulation and transit to the plants. In some wine-making regions such as Chile, irrigation is necessary to grape formation and growth. Nevertheless, keeping the vines under a regular deficit of water is a common practice applied by viticulturists in order to stimulate the root growth of the plant. While the soil generation process enables to maintain an aerated structure optimal for rain and irrigation waters infiltration, an active microbial life in the soil increases the water retention capacity. In particular, Trouvelot et al. underline the capacity of arbuscular mycorrhiza to increase the drought resistance of inoculated vines (2015).

- *Landscape elements management:* where most of the articles consider the soil generation and fertility management at the plot and field scale, Castañeda et al postulate that natural ecosystems within and around the vineyards' plot can be a source of nutrients and key micro-biodiversity for the soil generation and Fertility processes (Castañeda et al., 2015).

Water provision

Defined as both a provision and supporting service by the MEA, water provision is perceived differently according to the wine-making regions: while being the result of the mere natural processes (rainfall and water flows) for the template and humid Mediterranean viticulture regions, it is the fruit of the interaction of humans with natural water flows to provide irrigation to the vineyards in dryer climates. The perennation of water provision ES is tightly linked to the need for irrigation. In Chile, where almost 80% of the vineyards surface are irrigated (Gil and Pszczolkowski, 2007), the pressure on water provision ES is very high. Indeed, in 2013 95% of the Chilean wine-making areas were already under water stress, generating the need to move the viticulture areas further south where water is still relatively abundant (Hannah et al., 2013). Interactions with following practices were underlined in literature:

- *Soil cover:* water provision is the factor limiting the application of a constant soil cover on the vineyards. Indeed, under the dryer climates were the main source of water is superficial irrigation, inter-rows cover crops or weeds come to compete with the vines for water resources (Danne et al., 2010). Paradoxically, ensuring a constant or seasonal soil cover was shown to improve soil structure thereby enhancing water infiltration in the soil (Salomé et al., 2015). Both Danne et al. in Australia and Tompkins et al. in New Zealand mentioned the native weed species, adapted to high water deficits, as a

promising solution to ensure a soil cover without competing too hard with the vine for water resource.

- *Variety selection:* while vines are already mostly maintained in a regulated new clones with higher drought resistance and deep rooting capacity are being developed to face the water-provision challenges
- *Canopy management and vine-rows' orientation:* the vineyards' exposure to the sun regulates the water need of the vines. An important saving in irrigation can be done by orienting the vine-rows according to the precise need of exposure of the plants, or by applying a shading trellis protecting the vines from sun radiation during the critical times. At the vine's scale, a management of the canopy in order to ensure sufficient air circulation while providing enough shade to the grape clusters can also consequently regulate the plant's need and avoid the use of water-demanding cooling techniques such as micro-misting (Hannah et al., 2013).

Water quality

The regulation of water quality is mostly ensured during the infiltration processes of the water in the soil as a result of bio-physical interactions. It is impacted by following practices:

- *Fertilization:* the management of the nutrients input is essential to avoid nutrient leaching through underground and flowing waters. In Chile, where most of the soil have low nitrogen needs, the risk of nutrient leaching stays low but still shall be watched out (Etcheverry, 2014).
- *pests and diseases and weeds management:* pesticides and herbicides are potential sources of water contamination with synthetic chemical compounds or over concentration of sulphur and copper (Lamastra et al., 2010).
- *Irrigation:* the excessive extraction of water from the ground reserves for irrigation can lead to progressive salinization of the freshwater reserves (Lamastra et al., 2010)

Climate regulation

According to the MEA, "Ecosystems, both natural and managed, exert a strong influence on climate and air quality as sources and sinks of pollutants, reactive gases, greenhouse gases, and aerosols and due to physical properties that affect heat fluxes and water fluxes" (2005, p. 111). Applied to viticulture, climate regulation service is identified in following ways:

- At plot and field scale, non-cropped tree species are often used as windbreak planted in rows around and within the vineyard according to the wind orientation and strength, also called "climate buffers". Windbreak trees can regulate the wind strength on ten times their height (Etcheverry, 2014; Rochard, 2014).
- The ecosystems surrounding the vineyards play a role in the regulation of temperature and humidity conditions of the vineyard. Forest ecosystems in particular template the temperatures variations and maintain a constant humidity that can both be an asset for the vineyards under dry climates, and a constraint under more temperate climates (Rochard, 2014)
- Compared to other crops, vineyards agroecosystems have a high carbon sequestration potential as perennial woody species (Brunori et al., 2016; Salomé et al., 2015). Moreover, vineyards properties with large non-cropped areas, as it is often the case in the new world's wine-making regions have a very high potential in planting forests that can play the role of real carbon sinks (Tompkins, 2010).

The climate regulation ecosystem service mainly depends on following practices:

- *Soil cover:* vine plots with constant soil cover can have a positive carbon balance (i.e. sequestering more C than emitting), while the vineyards with bare soil inter-rows have a negative C balance because of higher soil respiration rate (Brunori et al., 2016; Salomé et al., 2015).
- *Vines' canopy:* the canopy development determines a micro-climate around the grape cluster. According to the local climate of the vineyard, canopy management through indirect vigour control or thinning actions, is a key practice to control the fungal diseases pressure at plant's scale (Altieri and Nicholls, 2002; Etcheverry, 2014).

Biodiversity and genetic diversity conservation

Biodiversity and genetic patrimony conservation has a particular valuation potential in the wine-making world through the notion of "terroir", "a concept which refers to an area in which collective knowledge of the interactions between the physical and identifiable biological environment and applied viti-vinicultural practices, providing distinctive characteristics for the products originating from this area" (OIV, 2010). The knowledge and integration of the special biological context of a precise place has a central importance in the creation and conservation of a terroir for the wine. Casteñeda et al underline the crucial importance of the soil micro-fauna diversity in the expression of a wine tipicity. Ongoing studies of the WCCB team tackle the

question of the possible participation of native yeasts in the alcoholic and malolactic fermentations leading the wine making process. At the landscape scale, the new-world wine making properties sometimes encompass large non-cropped areas with high potential of native ecosystems conservation or restauration that can be privileged places for biodiversity and genetic patrimony conservation (Steel et al., 2017; Tompkins et al., 2012). Further interaction of this ES with viticultural practices are:

- *Pests and diseases:* the application of fungicides kills soil and above-ground fungal diversity and thus reduces the expression of the local characteristics of the ecosystem in the vineyard ecosystem (Castañeda et al., 2015; Trouvelot et al., 2015)
- *Soil cover:* the use of cover crops offers habitat for spontaneous biodiversity and can constitute real ecological corridors when kept all year round (Danne et al., 2010; Pain et al., 2016; Rochard, 2014). Moreover, ensuring a species continuity between surrounding ecosystems and the vineyards through the implementation of native cover crops emphasizes exchanges between these two ecosystems (Danne et al., 2010)

Cultural ES

Cultural ES encompass the way people perceive and value the landscape formed by the vineyards and their surrounding ecosystems. Winkler and Nicholas affirm that cultural ES highly vary according to the wine-making region, taking multiple facets according to the cultural relation to landscape, the history of viticulture in the landscape and the way it is practiced in this context (2016). Their study enabled to notice a difference of perception of the cultural ES between the wine-makers, the wine-consumers and the local people. They underlined the influence of the "farming styles" on the way viticulturists perceive cultural ES: the producers focused on productivity are more sensitive to ES directly benefitting the production of grapes and wine, while the producers encompassing an "environmental stewardship" in their practices are more sensitive to indirect benefits of their activity (Winkler and Nicholas, 2016). The experience of Orre-Gordon et al. confirms this view. They showed how the transition of a whole wine-making region to sustainable wine production resulted in an improvement of the relationships between the locals and the wine-makers, emphasizing the development of recreational and touristic attractive activities within the vineyards (2013). Overall, the cultural services most recognized in the wine-making context are the aesthetic balance of the vineyard landscape mixed with natural ecosystems and the recreational activities (œno-tourism, educational or leisure trips on the vineyard property).

The cultural identity linked to the vineyards is being strongly valued in the historical wine-making regions (Orre-Gordon et al., 2013; Rochard, 2014; Winkler and Nicholas, 2016), while vineyards can be perceived as a disturbing landscape change in the countries where viticulture is currently being introduced.. Cultural ES are linked to following practices in the literature:

- *Soil cover:* having a soil cover on vineyards generates a feeling of continuity with the surroundings, increasing the beauty and the balance of the global landscape (Orre-Gordon et al., 2013; Tompkins, 2010).
- *Landscape elements:* the use of native species within and around vineyard's plots increases the continuity and coherence of the global landscape where native ecosystems are still cohabiting with the vineyards (Tompkins, 2010)
- *Land conversion:* people react differently to vineyards' expansion according to their attachment to the initial landscapes. Generally, locals attached to historical landscape fear the vineyards' expansion while people involved in wine production perceive the economic benefits generated by the evolution and integrate the land conversion as a positive event (Winkler and Nicholas, 2016).

Wine provision and quality, provision of natural products

These two last ES are very rarely mentioned in literature. The quality of a wine is very complex and subjective concept. Nevertheless, the internationalization of the wine-market resulted in the emergence of standardized parameters for grapes influencing the final wine quality were established. The provision of a wine of sufficient quality is recognized as an Ecosystem Service in two papers, thus acknowledging the high expression of the natural ecological processes in the final product (Tompkins, 2010; Wheeler et al., 2005). Wheeler et al (2005) link the optimization of wine quality to the implementation of permanent soil cover in the interrows in order to control the vines' vigour in rich soils. The provision of natural products like fruits or timber wood is mentioned by the project Life + BioDiVine as a possible valuation of landscape elements (Rochard, 2014). It is of secondary importance in this very specialized sector.

APPENDIX VI: Detailed description of the partner viticulturists' practices

The following paragraphs will come back to the practices presented in the literature review and present the different management choices made by the interviewed viticulturists and the underlying objectives. For each family of practices (recalled in table 4), a reflection about the drivers leading the management strategies will be led.

I.1.1. Yield and canopy management

All the viticulturists mentioned the winter pruning as a key step of the year, determining the yield of each plot. Most of the times, the pruning residues are being chopped in the inter-row to be either integrated to the soil, left as mulch on the inter-row or distributed to structure the ways between the vine plots. Chopping the residues was integrated since the viticulturists stopped burning them in order to prevent wood-fungi from developing. Complementary canopy works, such as green pruning in the spring time to adjust the final grape-yield, or leaf plucking to aerate the vine's canopy and optimize sun exposure, are practiced according to the budget allowed to each vine plot. These complementary works may be practiced in order to control the micro-climate of the vines and thus minimize the pressure of Botrytis c. on the grape clusters in the organic vineyards.

The yield and canopy management is a human-intensive labour, where possible mechanization is reduced to some vigour management operations. Therefore, the strategy chosen by the viticulturists mainly depends on the grapes yield and quality objectives mostly fixed by the oenologists of the winery: the more qualitative demand, the less yield and the more investment in human labour are required, while the more financial funds are given to the viticulturists for vines management.

I.1.1. Fertilization

The fertilization strategy of the vineyard is separated in two main kinds: the macro-nutrients (Nitrogen (N), Phosphorus (P) and Potassium (K)) are delivered to the soil according to currencies identified in soil analysis; while the micro-nutrients (Zinc (Zn) and bore (B)) are based on foliar analysis and sprayed to the leaves of the vines. The main differences between the strategies exposed by the viticulturists during the interviews lies in the macro-elements fertilization (NPK). It is interesting to notice that all the conventional vineyards visited had high yields objectives while the integrated, organic and biodynamic vineyards were setting their priority on high quality standards and limited yields. These objectives seemed to

condition the financial means invested in the fertilization programs. They are tightly linked to the management paradigm:

- The fertilization of conventional vineyards is a 100% based on mineral inputs. it follows a precise nutrient reposition program, based on the calculation of the NPK units that were quitted to the fields during the previous harvest and pruning, as well as punctual soil analysis. Nutrients can be brought in a solid form, using urea for N, nevertheless every time more viticulturists choose to use liquid fertilizers reputed to have fewer rates of atmospheric and lixiviation loss despite their higher costs.
- The organic and biodynamic viticulturists apply a 100% organic fertilization. They regulate their applications according to regular soil analysis and vines' vigour observation. As mentioned before, organic fertilization consists in enhancing soil life and natural liberation of nutrients available for the vines rather than counting the unities of each key nutrient. Viticulturists mentioned the fermented composts and guanos as the main inputs, mostly applied every two to three years to the plots. The composts generally partly come from the winery residues, while the guanos are bought from local farms or imported from Argentina or Paraguay. They sometimes complement their strategies with the use of organic fertilizers, such as some leguminous plant or algae extracts, humic-acids, or bio-stimulating inoculations of some mycorrhiza fungi or cellulolytic bacterias. Compost infusions are also often prepared in the spring and summer time and brought as fertirrigation. The implantation of nitrogen fixing cover crops in the inter-row or the integration of the residues of the interrows' mowing as a mulch, were also presented as alternative fertilization strategies.
- The biodynamic strategy compiles these practices and complement them with a set of self-elaborated preparations of plants and animal products fermented in precise conditions and integrated to the compost.
- The integrated vineyards present a mix of the organic and mineral fertilization strategies in different proportions. Some base their strategies on regular applications of compost and soil analysis enabling them to adjust the quantities of mineral fertilization they apply as a complement. Others, at the contrary, apply a fixed program of mineral fertilization, punctually complemented by the application of composts.

Fertilization program	**Number of viticulturists applying the program**

100% Mineral	2
100% Organic	8
Integrated : Mineral>organic	9
Integrated : Organic>mineral	6
Total	**25**

Table 1. Repartition of the fertilization strategies mentioned by the viticulturists during the interviews (the total number of viticulturists is higher than the 21 interviewees, as several vine-growers were applying several strategies at a time in their different fields).

I.1.2. Inter-row soil cover

The soil cover strategy of the viticulturists seems mostly linked to their vineyards' soil and climate conditions. They all use vegetal covers at least during part of the year. Strategies vary from one plot to other according to the particularities of the soil:

- In sectors with relative abundant water and / or deep soils with good water retention, the viticulturists can allow natural weeds to grow and cover the soil all year round. They control the height of the pasture with cattle grazing in the winter and regular mowing in spring, the weeds' growth being slowed during the summer drought. This strategy is often used in sloppy plots to prevent from erosion.
- In sectors where soils are thinner and / or present less water retention potential, the inter-rows are managed with a vegetal cover every other row in order to minimize the competition with the vines for water. Cover crops are sawn on the whole plot or natural weeds are allowed to grow in the autumn to cover the soil in the winter. They are then integrated to the soil in half of the inter-rows in the spring, leaving the ground bare during the summer. This strategy is also used in the vineyards where mechanical weeding strategy is applied, in order to liberate bare earth used to cover the weeds on the vine-rows.

The use of cover crops has many goals according to the species chosen and the period of time they are allowed to grow on the inter-row. They can be used as green manure for the soil, control agents of the vines' vigour through competition for water and nutrients soil pests control agents (mustard and chicory). They globally improve the soil structure and prevent from soil erosion, thus allowing the machines to circulate on the vine plots under humid conditions. The cover crops named by viticulturists were all exotic species, such as vetches, oat, clovers, chicory, festucas and mustard. The naturally growing species are also

most of the time exotic species which seeds were brought by the imported guanos or by the sheep left on the vineyards during the winter.

I.1.3. Inter-row soil labour

The strategy of soil labour chosen by the viticulturists mainly depends on the soil type, determining the water retention potential and the fertility conditions:

- The no-till strategy is chosen in fields with relative abundant water availability (rainfall and ground water) in order to enhance efficient draining.
- Superficial tillage is applied in fields with lower water availability in order to reduce competition for the nutrients and water resources.
- Some viticulturists still make the choice to plough at 50 cms to liberate nutrients in soils impoverished by many years of vine-growing.
- Overall, the regularity of use of heavy machinery results in the compaction of the deeper soil layer. Hence, some viticulturists proceed to the decompaction of the soil every two years approximately. Decompaction consists in passing a metallic arrow at 90 cms to 1m20cm deep in order to break and thus open the pressure pan, allowing better water circulation and roots growth.

I.1.4. Under-vine and weeds management

The management of the weeds and the soil under-vines is determined by the management paradigm:

- Organic and biodynamic vineyards rely on exclusive mechanical weeding strategies involving either human labour or machinery use;
- Integrated and conventional viticulturists all used chemical products with different strategies: the integrated management was based on an alternation of mechanical and chemical products application; or on the monitoring of some particularly aggressive weed species resulting in the focused application of chemical products. Conventional and some integrated vineyards made two systematic applications of chemical products (glyphosate) on the whole vineyards, complemented by additional application on focused contaminated areas.

The chemical herbicides mentioned by the viticulturists always contained at least glyphosate, sometimes mixed with pre-emergence products. The viticulturists expressed high awareness of the potential damages provoked by the repeated use of herbicides on soil

life and on vines, nevertheless they presented the moderate use of herbicide as a necessary harm for the grape production. Moreover, 17 out of the 21 viticulturists used animals (mostly sheep, horses and a few cows, llamas, poultry and alpacas) to graze the vineyards during the winter, enabling to consequently reduce the application of herbicides (two winter applications saved).

I.1.5. Pests and diseases management

Methods of pests and diseases managements follow a similar logic throughout all the studied vineyards. The phytosanitary program is based on regular monitoring: temperature and humidity conditions are being monitored to prevent the emergence of fungi (in particular Powdery mildew) and visual monitoring are being carried out at key moments to identify the presence of pests on the vine plots. This enables the viticulturists to adopt curative methods for most of the pests, applying the phytosanitary program only when a pest is being monitored over the limit for significant economic damage. For example, the "false red spider mite" *Brevipalpus chilensis*, an endemic acarian pest, is being treated with mineral oils in organic and some integrated vineyards and chemical products applications in conventional and other integrated vineyards. Most of the times, the treatments are adjusted to the monitoring of the presence of the spider's natural enemy (*Amblyseius chilensis*). The application program against powdery mildew is the same in all the vineyards. it is based on preventive applications of sulphur, strong inhibitor of the fungal activity. Applications are repeated after each rain and every seven to ten days according to the vineyards from the springtime until half of the summer, as long as the temperature and humidity conditions are favourable to fungal growth. The other common fungal disease due to *Botrytis cinerea* can be controlled by the vine's microclimate regulation with leaf plucking, the application of biocontrol agent Trichoderma. These two solutions being quite expansive, many vineyards use organically certified or conventional chemical fungicide in case of emergence of the fungus. Likewise, the exotic pest *Lobesia botrana*, introduced in Chile since 2007, is being regulated according to a plan published by Chilean agricultural ministry. This plan finances the installation of sexual confusion devices in the most affected vineyards of the country, while imposing the application of highly contaminating chemical products in the integrated and conventional vineyards of the least concerned valleys. Organic and some integrated vineyards of the moderately contaminated regions often choose to self-finance the installation of sexual confusion devices. Variations in the phytosanitary programs against other pests (mainly Mealybugs and Weevils) seem to

depend on the financial means on which the viticulturists disposed and on their personal knowledge about pests and diseases: the liberation of natural enemies is mostly being used in organic and some integrated vineyard with high quality wines. Interestingly, the viticulturists who mentioned "Macro-pests" damages, like wasps rabbits or birds, also mentioned that the natural ecosystems surrounding their vineyards were highly degraded or absent.

I.1.6. Irrigation

Irrigation practices are very similar among the vineyards. Viticulturists mentioned two main origins of the water they used to irrigate: the river-flows derived in agricultural canals and the extraction from deep ground-wells. As the rights on water-use are separated from the territory property in Chile, many of the vineyards counting on small rivers flowing in the gulches of their properties were not allowed to use it for irrigation. The preoccupation of the viticulturists for water-resource scarcity depends on the number of water rights they dispose on. Nevertheless, they all denounce the high competition for water resources at local scale. Almost all the vineyards' surfaces are equipped with drip-irrigation devices. The need for irrigation varies according to the yield objectives, the soil type and the age of the vines. The irrigation period starts in October and ends in February or March. Most of the viticulturists use satellites images and foliar analysis (with the Scholander bomb) to measure the vines' hydric stress and regulate the irrigation.

I.1.7. Landscape elements

The management of non-planted areas depends on the original situation of the vineyards:

- Some viticulturists are responsible of several hundreds to thousands of hectares apart from their vineyards. these properties are often located in the coastal mountain range, where the vineyards are planted in the lower parts of the gills. There, the native vegetation is allowed to grow in the gulches, around the water flows and on the hillsides forming natural ecological corridors.
- Others, often located in the central valley in a context more similar to vines' monoculture surrounded by urban area, other vines or crops, are (re)-creating ecological corridors, planting native and/ or exotic species on the ways or between new-planted vines' plots. Isolated trees are also voluntarily left in some vineyards.

- In several vineyards, a special area of the property is being dedicated to staff's personal agricultural activity, like bee-keeping, fruit trees or vegetable growing, bringing an interesting diversity in part of the vineyard.

Proportion of planted area in the total surface under responsibility	**Number of viticulturists**
Less than 25% vines	9
Between 25% - 50% vines	8
between 50% - 75% vines	1
More than 75% vines	3
Total	**21**

Table 2. Repartition of the viticulturists according to the proportion of planted and non-planted areas under responsibility (summing the surfaces for the people responsible of more than one property)

Vine-growers having less than 25% of vines count on large natural ecosystems surrounding their vineyards, while those managing more than 75% of planted surface work in landscapes more similar to monoculture. Viticulturists all expressed interest in better valuing the presence of non-vines vegetal species within and around their vineyards, in order to host natural enemies of the pests and increase the presence of prey birds. The participation to the WCCB program made them sensitive to the importance of privileging native over exotic species.

I.1.8. Cattle management

Animals are common on the visited vineyards. They may be used within and / or outside of the vine plots with different objectives:

- Sheep, horses and cattle are commonly left grazing on the vineyards during the winter time (17 out of the 21 interviewees mentioned this practice). They ensure efficient winter weeding.
- The sheep spend the summer to the Andes mountain, while the cattle and the horses are often transferred to the hillsides with degraded native ecosystems (transformed into pastures with scarce scrubs) to graze the dry herbs and thus slow fire expansion.
- Some organic and biodynamic vineyards use poultry on the vines plots in the winter to weed and decrease the pressure of Mealybug larvae in the soil.

- In some vineyards, Alpacas and llamas are used as decorative species within and around the vineyard

A few viticulturists, aware of the ecosystem degradation due to overgrazing, decided to forbid the access of the entire vineyard's property to local cattle and hunters (hunting being a common local activity) in order to restore native ecosystems around the vineyard. They often have to fence the property and set guardians on the doors to make sure their decision is being respected by locals.

Animals used	Number of vineyards	Functions
Sheep	6	winter weeding, (summer fire grazing)
Alpacas, llamas	4	Recreational
Cattle (cows)	2	winter weeding, summer fire grazing, biodynamic preparation
Horses, wild horses	3	winter weeding, summer fire grazing
Domestic birds (chickens, gooses, peacocks)	2	biocontrol of insect pests, winter weeding
None	1	

Table 1. Description of the animals used and their functions in the visited vineyards

I.1.9. Harvest

Harvest practices are the same in all the vineyards. They depend on the winery's decisions and on the availability of the machinery. Almost all the viticulturists manage both manual and mechanical harvests, most of them don't perceive major quality differences between these harvesting methods. They are all in favour of further mechanization of the harvest.

I.1.10. Land conversion

This topic has not been discussed with all the viticulturists as in some cases (the younger or more recently arrived people), no experience on the topic could be expressed. Most of the cases of land conversion exposed happened on former exotic-species plantation or on partially to highly degraded ecosystems. Today, the trend goes towards the reforestation of degraded native ecosystems on the hills surrounding the vineyards and around the water

flows in the gulches. Plans to buy new land in the southern regions of Chile to anticipate the evolution of climate were also mentioned several times.

APPENDIX VI: detailed description of the ES identified by the partner viticulturists in interaction with their practices

Interactions between ES and viticulture practices: the viticulturists' views

Just like for literature, the interactions between viticulture practices and ES mentioned by the viticulturists during the interviews were listed and counted. Figure xx shows the number of quotes in the interviews for each interaction identified by the viticulturists. Following paragraphs will explain how viticulturists perceived the interactions of their practices with each ES in their context. The points are the results of the gathering of all the sayings of the interviewees.

Biocontrol

Biocontrol was related to following practices:

Landscape element management:

- Abundant native vegetation around and within vineyards results in very low pest pressure whereas "monoculture-like" vineyards are more sensitive to pests and diseases. (re)-plantation of native vegetation around and within vineyards enhance biodiversity and stabilize sanitary situation of the vineyards, thus enabling to reduce phytosanitary costs.
- The ecological corridors formed by native and / or introduced vegetation host and enhance the introduced natural enemies' population (insects) and the balance in the macro-fauna (less rabbit pressure and more foxes on the vineyard). At the countrary, the degradation of the native ecosystems around the vineyards caused by overgrazing generates drought and increases the rabbits' pressure on the vineyards where they find water to drink in the irrigation pipes and fresh vegetal matter to eat (interrows cover and vines' leaves). Besides, avian biocontrol increases with a greater number of isolated trees within the vineyard.
- A viticulturist in contact with the technical school "Las Garzas" mentioned an ongoing study about the possibility to make a fungicide based on native tree species' extracts (Quillayes and Boldos) to treat powdery mildew.

Pests and diseases:

- Many viticulturists acknowledged the negative impact of pesticides on natural enemies. In particular, the conventional treatment imposed by the agricultural ministry against

Lobesia botrana has caused visible decrease of the red spider's natural enemy, thus provoking the increase of red spider's pressure on some vineyards.

- The adoption of monitoring practices for pests and natural enemies enabled the viticulturists to dramatically reduce their phytosanitary costs.

Interrows soil cover:

- Cover crops enhance biodiversity at all scales (in the micro-organisms of the soil, the insects and the fauna above ground). They act like "ecological corridors" within the vines plots. As a consequence, the pest pressure and the associated phytosanitary costs considerably decreased.
- Particular plant species can be used as allelopathic cover crops, for example, mustard is being planted by several viticulturists to prevent nematodes from damaging the plant's roots.

Cattle management: the organic and biodynamic viticulturists use poultry (chicken and gooses) in the winter to early spring-time to eat the larvae of Mealybugs.

Undervine management: monitoring enabled to notice the come-back of Brevipalpu chilensis' natural enemy since herbicide's applications were reduced.

Soil generation

The soil generation fertility was linked to following practices:

Cattle management: the constant presence of sheep, horses and cattle on the vineyards can cause soil compaction on the hills and the vineyard over time. Overgrazing opens native ecosystems and generates intense ecological degradation and soil erosion.

Fertilization: the integration of organic matter to the soil improves its structure and results in rapid improvement of the vines' vigor.

Harvest: the use of the harvesting machines can generate soil compaction. Some viticulturists started to install larger wheels to spread the weight of the machine more evenly. On the other side, the machines sort out the grapes from the leaves and racemes, that are immediately incorporated to the soil as organic matter.

Inter-row soil cover: the roots of cover crops aerate the soil and generate a better structure. Maintaining constant vegetal covers enables to enter with machines all year round.

Interrow soil labour: subsoiling restructure and decompact the soil. Some viticulturists consider that tillage have a positive impact on soil structure and aeration, while other denounce the negative impact of tillage on soil structure.

Irrigation: long and deep irrigations increase the soil volume explored by the roots in deep soils. They require a lot of water though.

Land conversion: the viticulturists who planted new vineyards on native ecosystems say they saw a lot of erosion happening the first years after vine's plantation

Undervines / weeds management: the mechanical weeding incites the vines' roots to grow deeper.

Yield and canopy: the integration of winter-pruning residues to the soil enhances soil structure. on the other side, soil characteristics influence the vines' vigour, thus determining the canopy works.

Soil fertility

The soil fertility was linked to following practices:

Cattle management: the sheep grazing on the vineyards in the winter-time fertilize with their excrements at minor scale. A viticulturist gave the estimation of 1000 kg/ha of sheep-excrements left per year. Cows are raised on the biodynamic vineyard to be slaughtered and use the organs for biodynamic preparations.

Fertilization: a good organic matter content of the soil brings soil fertility and increases the wine quality. Some viticulturists mentioned the fast effects of organic fertilizers (compost or bio-stimulators) on vines' vigor and productivity. At the contrary, some viticulturists argued that the use of urea as N-fertilizer killed the microbial communities of the soil.

Interrow soil cover: some viticulturists use N-fixing cover crops as "green-manure" (clovers, fava beans) in sectors of poor vine's vigour.

Interrow soil labour: tillage modifies the soil's microbial communities and "micro-climate". The transition to no-till enhanced soil life.

Irrigation: long irrigation is possible in deep soils and maintains soil life, increasing the root depth.

Undervines / weeds: the use of herbicides kills all forms of life in the soil. Indeed, some viticulturists observe more life in the soil since they reduced the use of herbicides. Having a

vegetal cover on vinerows may have a positive effect on soil life and structure, but their implantation is limited bv the water competition they represent for the vines.

Water provision

The water provision ES was linked to following practices by the viticulturists:

Interrow soil cover: the vegetal cover on the interrows works as drains during the winter in fields with high water retention potential. The water availability is the limiting factor for the permanent use of vegetal cover interrow: the vegetal covers are integrated to the soil when hydric stress gets too high.

Landscape elements: native ecosystems enable to preserve river flows and regulate water flows from the hills. Areas of monoculture are noticed more sensitive to hydric stress than areas with forest.

Yield and canopy: Fields with abundant water need more control of vigour through green pruning.

Water quality

Following links with the water quality ES were established by the viticulturists:

Fertilization: unbalanced fertilization can cause nutrient's lixiviation to groundwater. This is regularly controlled in most of the visited vineyards. Nutrients' inputs and form were adjusted over the past years to avoid lixiviation. For example, the Urea is progressively being replaced by liquid fertilizers, while every time more organic fertilization is applied.

Pests and diseases: some viticulturists mentioned the damages of potential residues of pesticides in the water.

Undervines / weeds: Herbicides can contaminate the waters

Biodiversity and genetic diversity conservation

The awareness of the viticulturists of the biodiversity and genetic diversity conservation led them to make following links:

Interrow soil cover: the introduction of exotic cover crops "invade" the ecosystem and doesn't create a real continuum of species with the native surrounding ecosystems. Introducing exotic species is thus considered as a perturbation by some viticulturists.Those showed high interest for the ongoing study on the potential benefits of native cover crops for the vineyards, which is being led in partnership with some of the visited vineyards

Climate regulation

The viticulturists who mentioned the climate regulation ES linked it to following practices:

Land conversion: vineyards surrounded by native forest ecosystems show a more template climate than vineyards planted in a "monoculture-like" landscapes of the same valley, showing hotter and dryer climate.

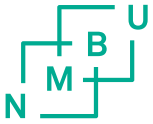
Landscape elements: one viticulturist uses pruning residues from Quillayes and Boldos to prevent early spring morning frosts by lighting smoky fires in the corridors of air-flow to template the above-ground temperature.

Yield and canopy: the presence of native forest ecosystem around the vineyards decreases sun-exposure and temperature on the plot's borders, thus increasing the canopy works (leaf-plocking) to increase sunlight exposure in these sectors.

Cultural ES

Among the cultural services, viticulturists only linked the aesthetic and cultural identity ES to practices. Aesthetic ES was linked to the landscape elements managements by a viticulturist, who designed a vineyard with particular attention to the balanced repartition of the ecological corridors with the vineyards' plots in order to ensure the beauty of the landscape. Other viticulturists mentioned the pleasure to see the green strips of the cover crops on the vineyards. likewise, biodiversity in general was mentioned as a beautiful asset of the vineyards

One viticulturist spoke about the still existing "mysticism" around the harvest, referring to a cultural identity that he considered in decline with the necessary mechanization of the harvesting process due to the current scale of production of his vineyard.



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