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Iago Otero Armengol

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Cover: “El pes que portem a l’esquena”, photograph by N. Valldeperas.

A les mares dels mons.

CONTENTS

1. PROLOGUE

Antoni Pascual was born in 1909 in a coastal town from Maresme County, in Catalonia. In 1930 he was ordained priest, and just two years later he became the priest of Olzinelles parish, in the coastal range of Montnegre (Zaragoza 2006: 123). Although still a rural parish, by that time peasants from Olzinelles had already started to abandon their farmhouses searching for better life conditions in nearby towns and cities, and the municipality of Olzinelles had already been annexed to that of Sant Celoni. In 1936, the priest Pascual was transferred to the small town of Matadepera, in the hillside of the pre-coastal range of Sant Llorenç del Munt, to replace an agitator right-wing priest whose personal safety could no longer be guaranteed by the left-wing municipal authorities (Aguilar 2010). The victory of the Republican left coalition in the Spanish national elections was very recent, and the military rebellion that was going to change the fate of the country and the town was already being planned by a large part of the Spanish and Catalan elites. When the priest Pascual arrived to Matadepera, he realized that his parishioners were mainly landless peasants devoted to dry land farming and tree felling, living in a small town surrounded by vineyards and gardens. But the outbreak of the Civil War after the military rebellion by General Franco and the resulting revolutionary state in July 1936 obliged the priest to flee in order to save his life.

My supervisor Martí Boada was born in the town of Sant Celoni ten years after the end of the Civil War. He was son and grandson of humble forest workers who provided him with "very different ways to understand the forest than those given in the academic boxes" (Boada 2001: 3) before entering the University as late as in the 1990s. As he writes in his PhD dissertation "when I was a child I travelled across low Montseny's and Montnegre's forests with my mother, to do an activity that was a punishment for the women of the humblest families: to gather acorns" (Boada 2001: 4). When they arrived to town at twilight, her mother carrying a sack of sixty kilos in her head, they sold the acorns at a derisory price to a pig dealer. Olzinelles valley, located a stone's throw away from Sant Celoni, was for him a "school of nature". At the beginning he went with his father to fell firewood or to capture an appetizing water vole in the stream. Later, he started studying its linked social-ecological system focusing particularly in the interaction between humans and the rest of animal species, from the vantage point of being an insider and living in Ca l'Agustí, one of the farmhouses of the valley bottom.

It is an early summer's day of 2004. Martí Boada leaves Sant Celoni and enters AP-7 motorway making his way towards Matadepera. At his back, a completely different Olzinelles from the one priest Pascual knew in the 1930s. No peasants are working their lands and forests. Instead of them, government employees manage "nature" under the protection of a natural park. Some developments sprawl in the hills of the old municipality. After one hour Martí arrives to Matadepera, where I have been living for more than twenty years. Luxurious mansions have grown in former vineyards, and the rural town of the 1930s is now one of the wealthiest municipalities in Catalonia. Watered grass lawns cover about the same area as the remnants of farm land, saved from aggressive urbanization thanks to a natural park that "protects" about 60% of the municipality. Martí, former professor of mine in the Bachelor's Degree on Environmental Sciences, is meeting me and the well-known local eldest Pintoret. Pintoret is going to be our guide in a field trip across Matadepera, planned to prepare the course on landscape change that Martí and myself will give in the Summer University of the town. I have just finished my Bachelor's Degree and I am about to start with my PhD.

There is a very strong emotional link with Olzinelles and Matadepera, the study areas of this thesis; they are our home and body. And there is also a strong concern for being threatened by something. "It was at the end of the 1950s when we the children and young people from low Montseny grew up playing in Tordera River, while our adults kept their harvests going with the irrigation waters from Tordera, when suddenly the first pollution events appeared. At the beginning we were amazed, because water changed color overnight. But soon jokes made way for fear when we started seeing the death of fishes until they completely disappeared, and how our parents' harvests were scorched when irrigated with polluted water" (Boada 2001: 6). In my case, the large fire of Sant Llorenç del Munt in August 2003, with five people killed and thousands of hectares of forests devastated, made me feel absolutely helpless since I was living in the Italian Dolomites and I could only watch it on the TV. Although the flames did not reach Matadepera, many volunteers and firemen from the town took part in the extinction works. Some friends of mine were almost burned alive when trying to escape from the flames with the fire engine, while others like Pintoret Junior had to run for hours across the mountains with the fire front advancing without respite in their back.

Unlike Martí, I am not from the countryside, and neither is my family. I felt nostalgia for a world which I had only guessed at when seeing old photographs from the town or walking around the old fields and farmhouses in Sant Llorenç del Munt mountains. I also had the feeling that threatening wildfires occurred precisely because the rural world was not anymore "The World". I wanted to understand such a dramatic transformation. I was very much attracted by the experiences and languages of the eldest of the town, but I wondered how to include them in my research without being disrespectful to them or misunderstanding their thoughts, shaped in a completely different social-ecological and mental setting than mine's. Moreover, given the intangible and vanishing nature of local rural knowledge in an urbanizing metropolis, I wondered not only how to capture it but how to include it in an academic work without reducing it to numbers. What was I expecting to get from this knowledge? Or rather the question should be: What was I expecting to get from the knowledge carriers?

I also found particularly tempting and challenging to build an integrated approach in the study of land change drawing on different disciplines from the social and the natural sciences to achieve a holistic view while at the same time keeping the rigor required in academy. When I attended meetings gathering scientists, land managers and policy makers, I realized that they were talking to each other in different languages, regardless of the scale and the scope of the meeting. In scientific conferences on sustainability or conservation most of the participants complained about the difficulty of producing politically relevant scientific research. For me, this was another cause for concern, especially at the local level. I had the necessity to know if action-oriented research practices stemming from real world conflicts could contribute to solve this gap and to lead the social-ecological system towards a more desired and resilient state in terms of ecosystem services and human well-being.

What follows is just one attempt out of the many other possible paths hidden out there.

2. INTRODUCTION

2.1. This thesis in brief

2.1.1. Background and motivation

As a result of increasing pressure on natural areas and of greater concern for the environment, in the last decades the Catalan society has implemented a network of natural protected areas covering about 30% of the whole country. Although the network has undoubtedly protected many areas against their major threats, i.e. urbanization, it has not been as successful as intended in the conservation of biodiversity and in the development of local peasants, shepherds, and foresters, whose productive activities have been often seen as having a negative impact on the ecosystems to be protected (Boada and Otero 2006).

This is a common opinion worldwide. Some conservation scientists, NGOs and policy makers believe that environmental degradation is the outcome of inadequate and unplanned local management practices based on poor knowledge by peasants, and that conservation strategies should be based on expert knowledge and rational planning of resource use (Ulloa 2002). In Latin America, for example, the "fact" that land abandonment following rural outmigration to urban centers is promoting ecosystem recovery has lead some scientists to suggest that social and conservation policies should focus on preparing rural migrants for an urban environment, where social issues like health, education, and job opportunities can be resolved more efficiently, rather than subsidizing inefficient systems of production in marginal areas (Aide and Grau 2004). These recovering ecosystems would provide ecological services for the growing urban population and would support much of the biodiversity that has conservation interest, while improved efficiency in high-yield agriculture concentrated in the most productive soils would help to provide food and biofuels to the increasing global demand (Grau and Aide 2008).

Highly reactionary and unfair policies can stem from this analysis. Scientific knowledge, considered to be objective and source of authority, is always driven by political and cultural agendas (Arnold 2000). In fact, protected areas are a particular

way of seeing, understanding, and producing nature and culture, as well as managing the relationship between the two, often with high social and economic costs for local or indigenous population (West et al. 2006). Excluding local people from conservation strategies and protected areas not only threatens their livelihoods but also the biodiversity that is to be conserved, since what are thought to be pristine ecosystems are actually cultural landscapes that depend on particular management practices (Reyes-García 2008). The exclusion of humans and traditional resource use in natural protected areas disrupts long processes of storing and transmission of local ecological knowledge systems that have great value for sustainable ecosystem management and biodiversity conservation, not only in developing countries but also in industrialized ones (Gómez-Baggethun et al. in press).

On the contrary, strategies of conservation and poverty reduction should be tackled together, since biodiversity loss and poverty are linked problems (Adams et al. 2004). Although community-based conservation has been controversial because community development objectives are not necessarily consistent with conservation objectives in a given case (Berkes 2004), listening to silenced voices of peasants managing their resources is an essential step to succeed in biodiversity conservation. From an ethical point of view, and as opposed to an exclusively science-based conservation, we need to "listen, understand and respect micro stories; stories emerging from a context, a region, a minority social group, an endangered species, a landscape" (Noguera 2007: 12). Especially relevant in this regard is the work on the management of common-pool resources, showing how locally evolved institutional arrangements governed by stable communities and buffered from outside forces have sustained resources successfully for centuries (Ostrom et al. 1999; Dietz et al. 2003).

The idea that productive rural activities and conservation are not compatible is, to a large extent, related to the theoretical framework of forest transitions. After large and long declines in forest cover, several countries experienced an increase in forest cover in the last decades. The so-called forest transitions take place as societies undergo economic development, industrialization and urbanization, and may be the result of planned tree plantations or spontaneous regeneration of forests in abandoned fields (Rudel et al. 2005; see also Rudel et al. (ed) 2010). These authors state that policymakers should enhance forest transitions given its potential for slowing soil

erosion, improving water quality, and slowing climate change through carbon sequestration. However, it has been clearly established in the hydrological science that an increase of the forest cover in a catchment determines a decrease in water resources from this catchment (Gallart and Llorens 2003; Bosch and Hewlett 1982). In this sense, carbon sequestration strategies do not consider the full environmental consequences of tree plantations, namely substantial losses in stream flow and increased soil salinization and acidification (Jackson et al. 2005). Moreover, lower pressures on forests in a given country are often achieved by importing products such as timber, hence increasing the impact on forest ecosystem services in the exporting countries (MEA 2005). In fact, the forest transition thesis reflects processes embedded in the history of midlatitude forest use, a history that may not play out similarly in other areas or biomes of the world, besides being more difficult to demonstrate at local to regional scales (Turner and Robbins 2008). Moreover, a decrease in the material appropriation of forest products does not necessarily mean a lower pressure on forest lands, as the forest transition pretends, especially if cities expand at the expense of forests or in areas that are simultaneously experiencing reforestation or afforestation processes creating a wildland-urban interface particularly vulnerable to fires (Stewart et al. 2007).

The debate about the implications of forest transitions brings us to another key issue of this thesis, namely the relation between the city and the countryside in the developing and developed countries. The dominant idea of the city and the countryside as two strictly separated domains is not consistent with the historical reality of the rural world (Saurí and Boada 2006). The historian Fontana (2000: 321) states that "peasants isolated from the cities, closed in their small world of subsistence economy and sharing a strictly local culture, never existed in Western Europe". Rather, Fontana argues, the countryside and the city have been always strongly related, and peasant families have not been self-sufficient because of the need to complete their agrarian income with the work in other activities. The "rural membrane" of a modern society, i.e. those areas and people extracting materials and energy from nature which will be consumed directly by humans (food and other goods) or transformed through industrial production and finally consumed (Toledo et al. 2002), has been strongly interlinked with the urban centers throughout history.

The rural-urban interrelatedness and the importance of rural activities for the maintenance of the urban centers have to be taken into account when studying the processes of land change, especially suburbanization. In the dominant discourse, the process of suburbanization is seen as spontaneous, inevitable and overall a social progress. Political leaders struggle against natural constraints to respond to an ever-increasing demand for water and land thus increasing overall social well-being within a single "urban vision" (Kupel 2003). Rather, the process of suburbanization may be understood as the outcome of political struggles between groups with different notions of progress and different "socioecological projects", where uneven power relationships result in unequal distribution of the costs and benefits of socioecological change among different social groups (Martinez-Alier 2002). Social power, violence and injustices in the course of socioecological change must not be neglected if a good understanding of landscape dynamics and successful conservation strategies are to be achieved. For example, although farmers have an essential function in the provision of food and other ecosystem services for the urban population, they are very often one of the most damaged groups in the process of suburbanization.

Back to the Catalan context, the importance given by society to the environmental impacts of agrarian intensification lead to ignore the impacts of land abandonment, which have gone almost unnoticed by public opinion (Saurí and Boada 2006). But the societal importance of the rural world is increasing as their role in food production, biodiversity conservation and landscape management is acknowledged by scientists, managers of natural protected areas and citizens (Boada and Otero 2006). In this context, the disappearance of local ecological knowledge related to rural activities leads to a decreasing capacity of the social-ecological system to cope with an increasingly changing environment (Berkes et al. 2000; Olsson et al. 2004). This has promoted several initiatives to avoid or to reduce the erosion of local knowledge.[1] However, it is not possible to save the knowledge if the social-ecological interactions and management practices where it is embedded do not exist anymore.

[1] Some institutions working on this issue with on-line information are: Fundació del Món Rural; Centre de Promoció de la Cultura Popular i Tradicional Catalana; Escola Agrària de Manresa; Les Refardes-Gaiadea; and Laboratori d'Etnoecologia de l'Institut de Ciència i Tecnologia Ambientals (UAB).

2.1.2. Aims

At the heart of these debates there are paramount issues concerning how the human is conceived in relation to the natural and how are human beings thought in relation to other human beings. The studies on land change and conservation of biodiversity and ecosystem services are too often based in binary distinctions between society and nature; city and countryside; conservation and development; protected and non-protected areas.

This thesis is aimed at helping to overcome such divides to better understand the coupled social-ecological systems and its change over time in a holistic and relational way. It intends to show that productive rural activities are not necessarily incompatible with conservation of biodiversity, and that some of these activities, even when they are quite integrated with market economies, are indispensable to conserve the cultural landscapes that modern urban societies want to protect. In some cases, neither the state nor the market alone, but complex institutional arrangements evolved in particular sociocultural settings have been able use the natural resources sustainably, and the abandonment of the management practices that depended upon such particular arrangements may have a negative effect on biodiversity. This thesis also asks whether forest recoveries have a negative effect on water discharge from the catchments and on the biodiversity from open habitats at a local scale. It will also explore the transformation of the countryside during the process of industrialization and urbanization to support the notion of historical interrelatedness and hibridity between the rural and the urban domains, and show that suburbanization is the outcome of political struggles between different social groups that perceive unequally the costs and benefits of socioecological change. Large injustices against vulnerable social groups and environments are committed in the name of progress.

The Mediterranean is a particularly illuminating region for the aims of this research, since it is considered a hotspot of global biodiversity which itself is a consequence of the integration between natural (land heterogeneity) and human (stewardship) processes throughout millennia (Farina et al. 2003). Mediterranean biodiversity is highly threatened because of their particular sensitivity to land-use change and invasion of exotic species (Sala et al. 2000). The north rim of the basin, with some of the most

developed countries in the world, is particularly suitable for this research since long processes of industrialization and urbanization have occurred, while at the same time there is still a number of important semi-natural areas with crucial social and ecological functions (e.g. Natura 2000 network). Among them there are many mountain areas, where especially large decreases of ecosystem services (e.g. declining water availability and increasing risk of forest fires) as a result of global change are expected to increase vulnerability (Schröter et al. 2005). This thesis is focused in the Barcelona Metropolitan Region (Catalonia), one of the largest cities in Mediterranean Europe, more specifically in two mountain areas: Olzinelles, in Montnegre mountains, and Matadepera, in Sant Llorenç del Munt mountains. It is aimed at gaining a deep understanding of the rural-urban socioecological transformations experienced by these Mediterranean mountain areas, shedding light in their driving forces, and showing some of the consequences and challenges for a sustainable management. It also wants to provide politically relevant information and narratives to empower the social action towards more desirable social-ecological systems.

2.1.3. Structure

In the first place I present some theoretical insights (Section 2.3) that may be considered a socioscientific response to the global environmental crisis (Section 2.2), and that are relevant for this work. In both sections special attention is paid to the Mediterranean region, since some of its specific features and processes are very important to understand the dynamics of the social-ecological systems analyzed in the case studies. In section 2.4 I formulate the research questions. In section 2.5 a brief description of the Barcelona Metropolitan Region and the study areas is given, and a review of some existing studies done by ecologists, geographers and agrarian historians from which specific questions emerge for this work is provided. In section 2.6 an outline of the methods is given, together with a brief description of the case studies. Next I present the three case studies (Chapters 3, 4, and 5). The abstract of each chapter and the publishing status and co-authors are included in the title page of each one. Synthetic descriptions of the study areas, including relevant details for each case, are provided in the initial sections of the chapters, while figures and tables are grouped in the final section of each one. In chapters 4 and 5 references to archival data and additional explanations are provided in footnotes with an independent numeration for each chapter. The page of the

source is indicated when referring to very detailed information (especially in chapter 4) or when making literal quotes. A general conclusion of the research is presented in chapter 6. The epilogue ends with an optimistic view of social-ecological transformations and the future of humanity in the Earth.

2.2. Global change and crisis

Global change can be considered a set of environmental changes in the Earth's system caused by a fast increase in the human population, in the consumption of energy and materials, and in the disposal of wastes and pollutants within an economic system based on unlimited growth. Although the planet has been changing since its infancy, the speed at which the current changes are taking place and the fact that they seem to be caused by only one species (*Homo sapiens*) leads to consider global change a unique phenomenon in the history of the Earth (Duarte (ed) 2006).

Warming of the climate is unequivocal, and there is very high confidence that the global average net effect of human activities since 1750 has been one of warming due to increased emissions and atmospheric concentrations of greenhouse gases (IPCC 2007a). Land-use change, generally considered a local environmental issue, is becoming a global phenomenon. Croplands, pastures, plantations, and urban areas have expanded at the expense of forests and natural ecosystems (Foley et al. 2005; Ramankutty and Foley 1999). As a consequence of land-use change, climate change and other human-induced changes in the global environment, global biodiversity is declining at an unprecedented rate (Hassan et al. (ed) 2005; Vitousek et al. 1997), being habitat destruction the leading cause of species extinction (Pimm and Raven 2000). Loss of biodiversity is paralleled by and seems interrelated to the extinction crisis affecting linguistic and cultural diversity (Maffi 2005), both being under threat by the same driving forces (Sutherland 2003).

Although the changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, they also undermine the capacity of ecosystems to provide the goods and services upon which human life depends (Foley et al. 2005). Levels of poverty remain high, inequities are growing, and many people still do not have a sufficient supply of or access to ecosystem

services. The degradation of ecosystem services is harming many of the world's poorest people and is sometimes the principal cause of poverty (MEA 2005). Global change is undoubtedly a great human crisis, and unlike former dangers faced by humanity, it has a planetary scale, it affects the whole living system, and the success of the human species is not necessarily guaranteed (Ángel 1995).

The Mediterranean region is evolving at an accelerated rate under global change, albeit with particular drivers and outcomes deriving from specific features in terms of latitude, geomorphic and climatic heterogeneity, and history of human settlement. Land-use patterns are rapidly changing. While in the south rim of the Basin trends are dominated by a fast increase in firewood extraction, overgrazing, encroachment of agriculture, and regression of forest; the north rim is experiencing a decrease in farm land and an increase in forested area, often with young, poorly managed and fuel-accumulating forests (Puigdefábregas and Mendizábal 1998; Terradas 1999; Ramankutty and Foley 1999; Rudel et al. 2005).

High rates of urban sprawl occur (EEA 2006) with negative environmental effects such as landscape fragmentation (Lambin et al. 2001), high domestic water consumption (Domene and Saurí 2006), and increased vulnerability of houses and forests to wildfires (Badia-Perpinyà and Pallares-Barbera 2006). Land abandonment, agricultural intensification, urban sprawl and globalization are rapidly degrading the highly diverse cultural landscapes that resulted from the coevolution between natural and human processes (Farina et al. 2003; Farina 2000; MacDonald et al. 2000; Stoate et al. 2001)

2.3. Socioscientific response

2.3.1. A paradigm shift

Such a crisis is not only calling for a re-thinking of the forms of social and economic organization, but also for a profound revision of our knowledge structures. It is a crisis of perception, since we are using the concepts of an inadequate and old-fashioned view of reality (Capra 1998). Science, the mainspring of technological progress, must change radically if humanity is to manage its environmental problems; a new scientific method, which does not pretend to be either value-free or ethically neutral, has to be articulated

(Funtowicz and Ravetz 1991). Under what have been called "post-normal" conditions, applied science is not "normal" in Kuhn's sense, i.e. it is not conducted within unquestioned and unquestionable paradigms. Scientists provide narratives rather than predictions and participate as equals with the others (Ravetz and Funtowicz 1999). According to Morin (2007) the main limitation of the predominant style of doing research is the "simplification paradigm" (p. 29), a way to organize knowledge that eludes the increasing complexity of contemporary reality. Besides the big specialization of knowledge in unconnected fields there is a clear division between the natural and the social sciences. As an attempt to overcome excessive reductionism and to understand environmental problems, new epistemological and methodological approaches integrating the study of the natural and the social have emerged. These hybrid disciplines include environmental history, political ecology, agroecology, ecological economics, landscape ecology, and environmental sociology (Toledo et al. 2002). They may provide an appropriate conceptual and methodological approach to assess human influence on land-covers, overcoming mechanistic preconceptions and taking into account both biophysical and socioeconomic driving forces without falling into the nature/society dualism (Boada and Saurí 2002)

2.3.2. Environmental history

Environmental history, born with the concern for the environmental crisis by the scientific community and the ecologist movements of the seventies (Worster 1988), questioned the theoretical and methodological assumptions of general and economic history and tried to move beyond their oblivion of the social and ecological costs of progress (González de Molina 1993; Caracciolo 1988). Some environmental historians were soon accused to perpetuate the object/subject divide and to move from human exemptionalism to geographic determinism (Arnold 2000). Ángel (1995) states that since culture is formed along the transformation of the environment by humans, geographic determinism is partially right but is incomplete and reduces the complexity of historical causalities. Regarding human activity, some authors write environmental history assuming that nature has an intrinsic harmony and that human action is destructive, but it may be more appropriate to consider human action as an integral part of nature transformations (Palacio 2002). Actually, human induced changes in ecosystems are sometimes explained as destroying harmonious natural states, forgetting

that biophysical world has its own historicity and is always changing per se (Boada and Saurí 2002). But the study of the relations between humans and their environment is not an innovation of environmental history, as some of their authors pretend. The contribution of traditional historical geography and Anglo-Saxon agrarian history, as well as the influence of French human geography in the old *Annales* school of historians Febvre and Bloch, should not be ignored (Fontana 1992)

2.3.3. Synergies between political ecology and land-change science

Political ecology may solve the problem of both geographic determinism and nature/society divide when writing environmental history, since it uses an intertwined perspective where the process of metabolic production fuses society and nature. From a political ecology perspective city and nature are not disjointed, antithetical entities; cities metabolize nature, producing new, urbanized natures (Swyngedouw 2004). This does not deny degradation; produced natures may be seen as better or worse according to different valuation criteria. Uneven power relationships produce uneven control of resources, and highly uneven and unjust (urban) landscapes with unequal distribution of the costs and benefits of environmental change among social groups (Martinez-Alier 2002). There is a need to visualize nature in the conflictive human history; to write histories about nature transformation by social groups fighting over the appropriation and the imaginaries of the desired nature (Palacio 2002), which in fact support the own political program of urban political ecology: to enhance the democratic content of socioenvironmental construction by identifying the strategies through which a more equitable distribution of social power and a more inclusive mode of environmental production can be achieved (Swyngedouw and Heynen 2003).

Political ecology and land-change science are two complementary approaches of addressing land-cover changes in coupled social-ecological systems. Both approaches have established that land-change processes are complex, with outcomes strongly influenced by place and history, though land-change science adheres to a postpositivist vision of science while political ecology is skeptical of postpositivism and the claims by some of its practitioners that it is the least subjective of the major explanatory forms (Turner and Robbins 2008). What seems clear in both of them is that human driving forces can not be always simplified into some universal categories such as population,

affluence and technology (the PAT equation). A review of case studies around the world by Lambin and colleagues concluded that neither population nor poverty alone constitute the sole and major underlying causes of land-cover change worldwide. Rather, peoples' responses to economic opportunities, as mediated by institutional factors, drive land-cover changes. Although opportunities and constraints for new land uses are created by local as well as national markets and policies, global forces become the main determinants of land-use change, as they amplify or attenuate local factors (Lambin et al. 2001).

In spite of the great progress in the study of land-use and land-cover changes, there is still a need for greatly improved understanding of the consequences of these changes, especially in the provision of ecosystem services and in the vulnerability of land systems (GLP 2005).

2.3.4. Ecological economics, agroecology and local knowledge

Another hybrid discipline relevant for this work is ecological economics. As opposed to neo-classical economics, ecological economics sees the economy as a subsystem of a larger finite global ecosystem from which it takes resources -energy and matter- and to which it excretes residues -material waste and dissipated heat (Martinez-Alier 2002; Martinez-Alier and Roca 2001). Capital accumulation does not take place on its own and is not only based on the exploitation of labor and technical change. Industrial capitalism advances into commodity frontiers because it uses more and more materials and energy, produces more and more waste, and thus undermines not only its own conditions of production but the conditions of existence of peripheral peoples, who complain accordingly in increasingly visible ecological conflicts (Martinez-Alier 2007). The global metabolic process, guaranteed by ecological unequal exchange, deteriorating terms of trade for natural resources, and sometimes by military power, is maintaining the centers of the world-system. This brings us to a fundamental question (Wallerstein 2007): is sustainable development possible within the framework of a capitalist system? Wallerstein states that there is no exit within our existing historical system, which is in a terminal structural crisis, a chaotic transition to some other system, a transition that will last at most another 25-50 years.

An attempt to look for alternative paths to the capitalist world-system may be found in the approach of agroecology. In the risk-prone, marginal environments of the developing world, untouched by modern agricultural technology, a new approach to natural resource management must be developed to adapt in a site-specific way to highly variable and diverse farm conditions typical of resource-poor farmers (Altieri 2002). While agricultural scientists develop new technologies based on scientific knowledge to modernize traditional agriculture, agroecologists and ethnoecologists study traditional technologies of peasants and indigenous societies to obtain modern scientific knowledge (Norgaard 1985). The knowledge systems of indigenous and rural groups have been referred to as "traditional ecological knowledge", "indigenous knowledge" and "local ecological knowledge" (Reyes-García and Martí 2007). However, the term "indigenous" overlooks the knowledge held by non-indigenous rural societies, while the word "traditional" might give the idea of a knowledge that is static and rigid rather than dynamic and evolving, besides wrongly suggesting that it does not occur at the same time tham other types of knowledge such as western science (Calvet-Mir 2007). Local ecological knowledge seems to be the less problematic term to refer to "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes et al. 2000), probably one of the best known definitions in the literature. Due to its capacity to adapt to changing environmental conditions and perturbations, local ecological knowledge may play an important role in creating alternative management strategies of natural resources (Reyes-García 2008), specially in the current crisis where contemporary science, by itself, is not able to face environmental problems (Funtowicz and Ravetz 2000).

2.3.5. Sewing the ontology of split

The review by Goldman and Schurman (2000) identified four strands that are leading social theory to overcome the entrenched idea that nature and society are phenomenologically and scientifically distinct: ecological Marxism, with contributions from O'Connor, Benton or Harvey; political ecology, which is articulating the natural as constitutive of the social and vice versa (see section 2.3.3); environmental feminism (e.g. Haraway); and the sociology of science, seeking to expose the unspoken social and

moral commitments of scientific knowledge and its relation to power structures (e.g. Latour).

There are other attempts to move beyond the nature/society divide coming from the natural sciences. Landscape ecology, resulting from the junction between physical geography and ecology (Bocco 2003), and closely related to landscape planning and management (Vila et al. 2006), focuses on the study of and relation between landscape structure, function and change (Forman and Godron 1986). After some decades of research, the themes of landscape ecology, namely reciprocal interactions between pattern and process, heterogeneity, scaling, critical thresholds, and boundaries and flows, have enriched the discipline of ecology, and the persistent influence of land-use history on contemporary ecosystems has become increasingly apparent (Turner 2005). In the most innovative proposals, Farina uses the eco-field hypothesis to describe species-specific cognitive landscapes (Farina and Belgrano 2006) and landscapes as semiotic interfaces between resources and organisms, opening up a new perspective to a better understanding of the mechanisms that link patterns and processes across the landscape (Farina 2008, 2010).

The ontology of split has also been criticized from a philosophical point of view. Based on a deep review of philosophy's history, Ángel (2001) states that the deep change in the conceptual relation between man and nature that meant platonic dualism would be the cultural basis of current environmental crisis. The platonic division between sensitive world (body and nature) and real world (soul) would have been incorporated by Christianity into its dogma, and would have arrived to modernity under the forms of object and subject (Noguera 2004), separated nature and culture. The deconstruction of dualistic philosophies, together with tinged contributions from Hegel, Marx and Nietzsche, lead Ángel to build a new environmental philosophy intended to recover the unity between nature and culture (Ángel 2001).

2.3.6. The way out of crisis: shaping the change

Pessimistic views of the future of humanity can be heard everywhere: common people, social movements, politicians, artists, high-ranking officials, the media and, of course, scientists. According to Atkinson (2008: 81), "the overall conclusion is that our

civilization is poised to collapse (...) It is rather apparent that few meaningful measures will be taken to mitigate the collapse; on the contrary actions so far can be seen as actually exacerbating matters and thus making more catastrophic the final dénouement". As a consequence, "by the latter decades of this century, a radically altered world will have emerged, with a greatly reduced population living surrounded by the defunct debris of modernity" (p. 79). Actually, apocalyptic imageries and "ecologies of fear" sustain much of the public concern with environmental crisis, and especially with climate change, in a process of de-politization of the actions to undertake. The undisputed (except by a small number of maverick scientists) matters of fact of climate science are, without proper political intermediation, translated into matters of concern, and thereby relegated to a terrain beyond dispute that does not permit disagreement (Swyngedouw under review). Swyngedouw argues that the consensually established post-political frame is structured around the inevitability of capitalism and a market economy as the basic organizational structure of the social and economic order for which there is no alternative.

Recognizing that the way out of crisis is a political issue that depends on the political activity of everyone now and in the next decades paves the way for a more optimistic view. It is quite possible that the system that will emerge after capitalism is equally or more hierarchical and unfair than the present one, but it is also possible that we shall be living in a relatively democratic and egalitarian historical system reached through a more morally acceptable mode of global environmental change (Wallerstein 2007). Although the alternatives may be still poorly understood or under construction, it is known that some pathways are going in the wrong direction. Escaping from the economism, i.e. a complex of myths based on economy that, like traditional beliefs and scientific understanding, explains phenomena, facilitates individual and collective decisions, and gives meaning and coherence to our lives (Kallis et al. 2009), has been considered of paramount importance. Shedding light in the contradictions of the concepts used in sustainability science and action is also important. "Sustainable development" is in itself an oxymoron that leaves intact the heart of environmental problems, since "development" is historically and practically related to endless economic growth, and this can not be ecologically sustainable in a finite world (Latouche 2006; Fournier 2008). Crisis is thus an opportunity to transform social-ecological systems into a more desired state through adaptive governance structures that

self-organize as social networks with teams and actor groups that draw on various knowledge systems and experiences to learn and adapt to change (Folke et al. 2005).

2.3.7. The Mediterranean region: historicity and hybridity

In the Mediterranean region "natural" processes have been modified by human societies so much so that one can hardly think in an autonomous influence of such processes in landscape configuration (Boada and Saurí 2002). Landscape is seen as a palimpsest registering the footprints of different social communities that have followed one another (Tello 1999), where "ghosts of earlier times linger on the medium" (Marcucci 2000: 68). According to Marcucci, a more accurate metaphor is to think of landscapes as legacies: a landscape existing today results from previous conditions and events in that locale, and it follows that landscapes of the future will be legacies of the elements and processes occurring today.

Since the term "landscape" refers both to the physical environment and to the social representation and experience of it, there is a separation between those who argue that landscape is a good way to study the environment itself and those studying landscapes as a tool to explain the social representations of the environment, when in reality both should be considered in the analysis (Pèlachs 2006). Art, architecture, geography and landscape ecology have their own view of what is and what constitutes a landscape. It may be difficult to understand well all of them, and to know what we refer to when talking about a "landscape". The artist Perejaume, considered to have redefined landscape painting, makes it very clear: "I hate the word landscape, because it already tells nothing" (Pita 2009: 112). According to him, the word has been manipulated from a semantic point of view in the same way as the environment has been manipulated by sprawling buildings, industries and highways. Landscape today is nothing but a "junction of reflections prepared in enclosed and carpeted rooms" (Pita 2009: 112). Following Matthews and Selman (2006), it may be useful to think the landscape as a social-ecological system, emphasizing the integrated concept of humans in nature and stressing that the delineation between social and ecological systems is artificial and arbitrary (Folke et al. 2005). The review by Folke and colleagues enumerates other concepts that have been used by scholars with almost the same meaning: coupled human-environment systems, ecosocial systems and socioecological systems.

The historicity and hybridity of Mediterranean social-ecological systems calls for a high level of integration between disciplinary approaches and between models studying urban and rural areas (Verburg et al. 2004). Studying processes and not merely spatial patterns, extrapolating results in space and time, linking data of different qualities, and considering culture as a driver of landscape change are some of the challenges faced by the study of the driving forces of changing social-ecological systems (Bürgi et al. 2004). But probably the foremost challenge remains that of integrating research within the practices of the coproduction of science and application, as in many other regions worldwide (Turner and Robbins 2008).

2.4. Research questions

Several questions arise from the aims of this thesis, the theoretical insights and the particular features of the Mediterranean region:

1. Is the increase in forest cover after land abandonment experienced by Mediterranean metropolitan mountain areas leading to reduced water yields from the catchments? What is the role of changing climate and how does it interact with land-use changes in the hydrological balance of the catchments? May changes in the biodiversity of small streams be expected due to global change induced hydrological changes? Which specific features in highly forested mountain areas with Mediterranean climates need to be taken into account to fully understand the relation between climate changes, land-use changes and hydrological changes?

2. What was the role of rural mountain areas in the vicinity of growing urban centers during the industrialization process and how did it change over time? How did the social-ecological systems of such Mediterranean mountain areas adapt to the growing and changing demand of materials and energy while keeping options for self-subsistence open? How were the management practices of peasant communities related to their particular cultural contexts, and how did they contribute to the maintenance of diverse social-ecological systems? May sustainable management strategies emerge in contexts where private landownership has been fully established during the last centuries? What are the implications of land abandonment for the biodiversity of recent conservation interest? Is the debate about

the conservation of biocultural diversity, mainly devoted to indigenous and rural groups from developing countries, useful in industrialized countries too?

3. How different visions of the future by different social groups may collide in the process of suburbanization of the countryside? Whose socioecological projects prevailed and why? How have small and landless peasants been affected by the processes of suburbanization in the cities of the north rim of the Mediterranean basin? What should be learnt from their "micro stories" and memories? What social and ecological costs have been inherited from the chosen paths of development? Why some areas of the countryside specialize in elite suburbanization and others follow the path of land abandonment?

2.5. Study areas

2.5.1. The Barcelona Metropolitan Region

The Barcelona Metropolitan Region (BMR) is an appropriate setting to answer the research questions by studying the socioecological transformations from rural to urban mountain areas, their driving forces, consequences and challenges for sustainability. About 4.9 million people, i.e. two thirds of the whole Catalan population, are living in 3200 km^2, i.e. 10% of the country (IDESCAT 2010). The BMR is one of the most densely populated regions in Europe. It is structured in a large, diverse and compact centre (the municipality of Barcelona), a very dense first metropolitan ring (32 municipalities), an extensive second metropolitan ring (124 municipalities), and 7 sub-centers constituted by municipalities between 50,000 and more than 200,000 inhabitants (Catalán et al. 2008), such as the cities of Terrassa and Sabadell (see fig. 1 from section 5.6). Two coastline-parallel mountain ranges dominate the BMR, namely the coastal range, with Garraf, Collserola and Montnegre mountains, and the pre-coastal range, with Montserrat, Sant Llorenç del Munt and Montseny mountains.

Contrasting topography (elevation ranges from 0 to 1700 m a.s.l.) and climate (with gradients NE–SW from moist to dry and SE–NW from less to more continental) brings about a greater variability than found in general Mediterranean conditions, which is responsible for high landscape heterogeneity. Forests, shrubs and grasslands covered

60% of the BMR in the year 2000, while croplands occupied 21%. Coastal and pre-coastal ranges show homogeneous landscapes made up by forest and shrubs, whereas lowland areas are dominated by croplands, forest-crop mosaics and urban areas especially close to the city of Barcelona (Marull et al. 2010). The BMR still has a number of important natural areas featuring considerable ecological diversity. It accounts for more than 40 habitats of European significance, including many species of fauna and flora that are either endangered or threatened with extinction (Marull et al. 2007).

The unfolding of industrialization and post industrialization lead to the substitution of forest fuels (firewood and charcoal) for fossil fuels as oil or methane (Boada and Zahonero 1998). Under current economic globalization, metropolitan (and Catalan) forests are not competitive enough given its low productivity, the mountainous relief and a high wildfire risk (Rojas 1999). As a result they are left unmanaged with well-known negative environmental effects, namely uncontrolled growth of vegetation, fuel accumulation and high intensity of potential wildfires. Decreasing prices of forest products and afforestation/reforestation in abandoned farmland are the main underlying causes of large wildfires, which exceed the extinction capacity and are responsible for dramatic human, socioeconomic and ecological impacts (Plana 2004; Piqué 2004; Castellnou et al. 2004). Large wildfires become specially threatening under extreme weather conditions (which are expected to increase), simultaneousness of fire events, and presence of highly vulnerable developments inside the forests (Badia-Perpinyà and Pallares-Barbera 2006; Piñol et al. 2005).

Mountain areas play a paramount role in the ecological functioning of the whole metropolitan region and are very sensitive to climate and land-use changes (Peñuelas and Boada 2003). It was precisely their high social and ecological value and the threat of urban spread that promoted an intense demand for protection by an ecologist movement arising during the pre-Transition period (Aguilar 2010). In the 1970s the first modern protection figures were implemented, including several emblematic mountains such as Montseny or Sant Llorenç del Munt. Nowadays, most of the natural parks and parks in the BMR are located in mountain areas: Montserrat; Sant Llorenç del Munt i l'Obac; Montseny; Montnegre i Corredor; Serralada Litoral; Serralada de Marina;

Collserola, and Garraf (Otero and Boada 2007). Our study areas are located in some of these highly threatened and highly valued mountain areas.

2.5.2. Olzinelles and Matadepera

The old municipality of Olzinelles, belonging to the municipality of Sant Celoni since 1927 (county of Vallès Oriental), and the municipality of Matadepera (county of Vallès Occidental), are located in the second metropolitan ring of the BMR (see fig. 1 from section 4.7 and 5.6), in the hillsides of Montnegre mountains and Sant Llorenç del Munt i l'Obac mountains, respectively.

The old municipality of Olzinelles has an extension of 2287 ha and it is located in the north-western side of Montnegre mountains, in the Catalan coastal range. Climate is Mediterranean, with a mean annual temperature of 14.6 ºC and a mean annual rainfall of 703 mm (see details in fig. 5 from section 3.6). Low granitic hills (maximum elevation reaches about 700 m a.s.l.) covered by dense holm oak and cork oak forests (*Quercus ilex* and *Q. suber*) dominate the landscape. Intermittent streams flow from the highest elevations to the Tordera River. In the valley bottoms, riparian forests (e.g. *Alnus glutinosa*) all along the streams give a shade of diversity to the evergreen setting. Fauna from western Mediterranean is well represented in Olzinelles, where it benefits from a large expanse of dense forests and the presence of small but indispensable agrarian habitats and water bodies (Boada 1984).

Settlement has historically been structured in dispersed farmhouses (*masos* or *masies*) that combined subsistence agriculture based on cereals and vines with the exploitation of forests. Some of the remnant fields, mostly located in the valley bottoms or in the surroundings of the farmhouses, have been converted to monospecific plantations of plane trees (*Platanus* sp.) or pines (e.g. *Pinus pinaster* and *P. radiata*). Farmhouses were organized around two parishes (Sant Esteve d'Olzinelles and Sant Llorenç de Vilardell) and a concentrated town never existed. During the 20th century most of the farmers in Olzinelles left their homes and moved to nearby towns and cities looking for better life conditions, in a process of rural exodus that was also occurring in other metropolitan mountain areas with dispersed rural settlement such as Montseny (Boada 2001) as the Catalan rural population decreased both in absolute and relative numbers

(Vidal 1979). Land abandonment not only affected the farmland, which was progressively afforested or reforested, but also the forests, where the uncontrolled growth of vegetation led to a process of fuel accumulation (Otero et al. 2008). In the last decades some housing developments sprawled in former forests, as it also occurred in many other mountain hillsides of the BMR (Piqueras 2009). Most of the area that was not urbanized (69% of the old municipality of Olzinelles) was included in the Montnegre-Corredor Park (Parc del Montnegre i el Corredor) in 1989, since then managed by the Diputació de Barcelona.

Figure 1: View of the study areas. On the left, the farmhouse Can Pau Foguera, in Olzinelles, where space is grown; oil painting on wood by Perejaume, 11 x 17.5 cm. On the right, *Amanita muscaria*, drawing by Pintoret, a well-known eldest from Matadepera (from the authors, with permission).

The municipality of Matadepera has an extension of 2537 ha and it is located by the south-western hillside of Sant Llorenç del Munt range and the eastern hillside of l'Obac range, both belonging to the Catalan pre-coastal range. The climate is mild Mediterranean, and the annual rainfall ranges between 675 mm in the town centre (423 m a.s.l.) and 850 mm in the mountain peak (1.107 m a.s.l.) (Martín and Moreno 1994). Landscape is characterized by the conglomerates deposited during the Eocene (see the cover's photograph) which have acquired particular shapes due to weathering. Vegetation is composed of holm oak woods (*Quercus ilex*), mixed with Aleppo and Stone pines (*Pinus halepensis* and *P. pinea*) in the lower parts of the mountain. There

are also communities of rupiculous plants on lithological outcrops and some deciduous trees such as hazelnut (*Corylus avellana*) in the northern and most humid slopes (Nadal et al. 2009). No permanent streams (neither with an intermittent flow such as some of the streams in Olzinelles) are found in Matadepera. The main torrent, *riera de les Arenes*, flows between Sant Llorenç and l'Obac ranges NO-SE and is most year dry, bursting occasionally in strong floods after intense rainfall episodes (Paül and Pérez 2002; Pérez 2002).

Similarly to Olzinelles, settlement has historically been structured in dispersed *masos* that combined subsistence agriculture based on cereals, vines and olive trees with the exploitation of forests. But unlike Olzinelles, a new concentrated town started to be build in 1768 along the road that connected Barcelona with Manresa (*camí Ral*), as landowners with property around the *camí Ral* subdivided part of their estates and leased plots to peasants who built their houses (Ametller 1997). During the 19th century the new town grew as landless or small peasants devoted to dry land farming and forest working arrived from nearby *masos* and towns. By the end of 19th century wealthy people from nearby cities started to spend their summertime in the town, which gained importance as a summer place for industrial bourgeois. The initial construction of second residences soon led to expanding low-density housing developments in former fields and forests, often after the dispossession of peasants from the lands they were cultivating from generations (Estany 2008; Ruiz et al. 2008).

To stop the encroachment of houses in the hillsides of Sant Llorenç del Munt, a mountain with high social and ecological value, after an initial protection in 1972 by the Diputació de Barcelona, a larger area (9600 ha) was protected in 1982, only to be designed officially as Natural Park by the Catalan government in 1987 (Estany et al. under review). About 61% of the municipality of Matadepera is now included in the Natural Park (Parc Natural de Sant Llorenç del Munt i l'Obac). The rest of the land is almost covered by wealthy housing developments forming an extensive wildland-urban interface (Stewart et al. 2007). Matadepera is now well-connected by car to Barcelona city and to the nearest metropolitan subcenters Terrassa and Sabadell, less than 10 km away from Matadepera (see section 2.5.1).

Both study areas, Olzinelles and Matadepera, may be representative of the mountain areas of the BMR in terms of altitudinal gradient, climatic conditions, water courses, vegetation, fauna, human settlement, land-uses, and socioecological transformations. The BMR is in turn a particularly suitable region to investigate the research questions, as argued above. A second reason to select these areas is that, even though it may be difficult to reflect it in a scientific language, living in a place allows a long-term monitoring of its social-ecological system. This means to start the research from an outstanding knowledge of the study areas: villagers and human history, current and past landscapes, paths and place names, biodiversity, institutional networks, sources of information and, foremost, conflicts and problems to be solved. In the next section I discuss some of the previous studies done by several authors in the BMR, identifying some important specific questions for the study areas that, besides helping to answer the general research questions, may add to the knowledge of land changes in the BMR.

2.5.3. Existing studies and specific questions

There are many studies on the complex dynamics and implications of land changes in the BMR. The decrease of population in the central area, the increase in peripheral areas that registered heavy losses of population only a few years ago, and the expansion of a dispersed city that creates new suburbs in the countryside are some of the main sociodemographic and spatial trends detected (Dura-Guimera 2003). As population from the city core has migrated to the suburbs, housing developments have sprawled, urban growth being six times larger than population growth between 1993 and 2000 (Catalán et al. 2008). The metropolitan planning system has not been capable of containing urban growth, the main impacts of sprawl being concentrated in agricultural areas (Paül and Tonts 2005). Rural areas have been converted to urban related uses at a high rate, causing considerable loss and fragmentation of the less transformed habitats (Marull et al. 2010). Small rural towns of the outskirts of Barcelona have been transformed to residential areas within the metropolitan dynamics, mainly with low-density and single-family developments (Estany et al. under review), commodified a-territorial residential landscapes esthetically homogeneous regardless of its location (Muñoz 2003). This leads to the following question: why some of these rural towns experiencing suburbanization turned out to be elite suburbs, while in other towns of the outskirts of Barcelona the new urban plots were sold to rural and less well-off migrants

living in the highly congested peripheries of Barcelona city? Are the high congestion of the city cores and the dry climates and beauty landscapes of particular places in the countryside explaining by themselves the demand for second residencies for rich holidaymakers?

Some interesting studies have shown how class and power relations appear to legitimize some particular socionatures over others, e.g. private and public gardens having a much larger social and institutional appeal and support than the vegetable gardens of the retired workers of the lowest classes (Domene and Saurí 2007). This insight leads to other important questions: whose socioecological projects prevailed in the process of suburbanization and whose projects did not? How did the different projects collide and how were some of them defeated? What is the relation between the process of suburbanization and the historical and sociopolitical changes experienced by the whole country during the 20th century? And perhaps more importantly, how have small peasants and their particular socionatures been affected by suburbanization or by land abandonment processes? Which are the inherited social and ecological costs from particular (chosen) paths of development?

Although the generalization of the dispersed urban model is confirmed, Catalán et al. (2008) show that the presence of numerous medium sized towns has proved to be a deterrent of excessive dispersion, polycentric metropolitan areas such as the BMR being more adjusted to absorb the negative effects of dispersion than monocentric ones. Although it seems clear that urban sprawl has to be contained, some valuation studies show that a less compact scenario would be welfare-increasing in aggregate terms, and that general proposals on compacting cities should not necessarily constitute a desirable planning goal (Garcia and Riera 2003). Marull et al. (2007) have provided a land suitability index aimed at delivering Strategic Environmental Assessment of developmental land uses for regional planning, according to different sub-indices concerning the vulnerability to impacts arising from implementing development proposals, the natural heritage value of the target area, and its contribution to terrestrial ecological connectivity. These authors have also shown the importance of the traditional agroforestry mosaic for the maintenance of the ecological quality of metropolitan non-built-up land (Marull et al. 2010). How were this agroforestry mosaics managed by peasant communities and how did they contribute to maintain what today is considered

a legacy to be protected, while at the same time making it highly productive for the urban centers? What are the implications of not managing anymore integrated agrosilvopastoral systems?

The relation between water resources and the process of urbanization has also received attention by researchers. Some works analyze the water demand policy (Saurí 2003); the influencing factors in urban water consumption (March and Saurí 2010; Domene and Saurí 2006); and the relationship between the management of the water cycle and social conflicts in the development of the city of Barcelona (Masjuan et al. 2008). To add to this last approach, an essential question would be: how, by whom and for what purpose water was mobilized in the process of suburbanization?

A second group of studies has focused on the effects of land-use changes and climate change on the ecosystems of the BMR. Temperature has increased by ca. 1 ºC in the last fifty years; while precipitation has not significantly changed (Peñuelas et al. 2002). Changing climate is already having important effects on the biodiversity of the BMR, with potential negative outcomes for the supply of ecosystem services. As a consequence of increased temperatures several species have shown significant phenological alterations, including advanced flowering, fruiting and leaf unfolding, and delayed leaf falling (Peñuelas et al. 2002). In Montseny mountains, northward shifts in geographical ranges have been detected in butterfly species (Parmesan et al. 1999). Agricultural intensification and urban development are transforming and fragmenting the landscape into an inhospitable and less permeable matrix for butterflies, and the negative correlation between species richness and temperature may lead to a predictable loss of diversity over the coming years, according to the most plausible scenarios of climate change (Stefanescu et al. 2004).

Higher vegetated land cover and aridity, together with water extraction for irrigation and urbanization, are decreasing the annual discharge of some rivers and aquifers of the Country (Beguería et al. 2003; Gallart and Llorens 2004; Liquete et al. 2009; ACA 2009). Is the increase in forest cover after land abandonment experienced by metropolitan mountain areas leading to reduced water yields from catchments with no extraction for irrigation and urbanization? What is the role of changing climate and how

does it interact with land-use changes in the hydrological balance of highly forested catchments?

Montseny's temperate beech (*Fagus sylvatica*) forest has shifted altitudinally upwards by ca. 70 m at the highest altitudes and has been replaced by Mediterranean holm oak (*Quercus ilex*) forest at medium altitudes (Peñuelas and Boada 2003). The decline of beech at medium altitudes is linked to a rapid and recent decrease in the growth of adult trees at the lower limit of this species' distribution, linked to increasing temperatures and exacerbated drought (Jump et al. 2006a). The upward shift of beech seems mostly due to warming, tough the cessation of the traditional shepherd fires has facilitated its expansion too (Peñuelas et al. 2007). Although beech populations have shown some capacity for an in situ adaptive response to climate change (Jump et al. 2006b), this response is not enough to avoid decreased growth. The cessation of traditional controlled burnings by shepherds has also promoted encroachment by shrubs and expansion of forest to the detriment of more diverse grasslands and heather pastures of European conservation interest (Bartolomé et al. 2005). Several spreading invasive species are threatening the conservation of native habitats and species (Broncano et al. 2005; Domènech and Vilà 2006; Sànchez and Pié 2008).

Several works in agrarian history have provided interesting and sometimes essential information to understand the coupled social-ecological system and its evolution, either in our study areas or in the counties of the region. Some of this works are Garrabou and Planas (1998), Garrabou and Tello (2004), Planas (2003), Cussó et al. (2006), Marull et al. (2010), Comasòlivas (ed) (2003), Roca (1996, 2006, 2008), Nadal and Urteaga (2001), and the classical work by historians J. Fontana and P. Vilar. These works analyze the management of the agrarian systems with an eye on fertilization techniques and integration of productive activities; shed light in the complex evolution of the rural productive systems; study the effects of increasing demography on landownership structures; calculate the social metabolism in past agrarian systems; analyze the specialization paths followed by different rural productive systems throughout the last centuries; and show how the urban growth in cities such as Terrassa would have never been possible without an adaptive countryside able to provide food and materials to the growing urban population. One of the issues that deserves further work is the important role that forests played within peasant communities and regional markets, as well as the

management of integrated agrosilvopastoral systems, especially from the end of the 19th century (R. Garrabou, personal communication). How did the social-ecological systems in mountain areas organize and adapt to the growing and changing external demands of materials and energy without loosing the local livelihoods of peasants? How did the role as rural membrane of mountain areas in the vicinity of growing urban centers change over time? What was the role of forest in the management of integrated agrosilvopastoral systems? How the national-to-global processes of modernization affected local livelihoods and creative life forms in the countryside of Barcelona city?

Several local histories of Sant Celoni (Abril 1998) and Matadepera (Ametller 1997, 2002) have been used as reference works, albeit very critically in some cases (see chapter 5). The work of my supervisor (Boada 1984, 1990, 2001; Boada et al. (ed) 2008) has also been an essential starting point, as well as the experience acquired during my Bachelor's Degree thesis (Borràs et al. 2005) and the Master thesis (Otero 2006). Other important precedents have been found in the proceedings of the periodical meetings on Sant Llorenç del Munt and Montnegre i Corredor mountains published by Diputació de Barcelona (*Trobades d'Estudiosos*), and in the Ecological Monitoring Schemes of both Natural Parks.

This thesis is aimed at helping to overcome the divides between society and nature; city and countryside, and conservation and development. In this way, it wants to contribute to a better understanding of the rural-urban socioecological transformation in Mediterranean mountain areas by achieving a relational knowledge. Some of the works presented in this section deal mostly with the social system (demographic trends, regional planning, economic preferences, consumption of resources) or with the natural system (climatic trends, changes in the phenology and the geographical ranges of species, decreasing discharges of rivers, biome shifts, invasive species), though naturally some of them refer to facts and features from the other "side" when they are needed to explain what they are analyzing. Other works are highly interdisciplinary - geography is an integrative science after all- but most of them lack an appropriate integrative approach to the study of land changes. The mentioned works by agrarian historians show a holistic view in general terms, especially those dealing with social metabolism, but a higher integration of disciplinary approaches may be very illuminating in some cases.

2.6. Methods, spatial scale and chronology

This thesis will try to answer to the general and specific questions by explaining histories that i) cover specific places, ii) describe holistic systems, and iii) reveal the keystone processes that shape the landscape over several time frames (Marcucci 2000). Although a detailed description of the methods may be found in the initial sections of each chapter, here a brief outline is given, particularly about the spatial and temporal scales.

In chapter 3 the effects of both an increase in forest cover after depopulation and land abandonment and an increase in temperature on the runoff and on the aquatic and semi-aquatic fauna species of Olzinelles catchment are evaluated. In chapter 4 the relationship between the abandonment of a diverse set of agrosilvopastoral practices placed in a specific cultural context and the process of biodiversity decline is explored in the municipality of Olzinelles. To capture the implications of such processes and to reinforce the idea that peasant communities had the ability to use the local resources in a sustainable manner, the concept of socioecological heritage is defined and discussed. Chapter 5 moves to Matadepera to reveal that the evolution from a small rural village to an elite suburb was a socio-environmental project well intended by landowning elites and heavily fought by others, thus questioning the notion of a spontaneous and unavoidable "progress".

Land-use changes are highly complex and scale-dependent. Variables that are driving changes at a given spatial and temporal scale may remain constant at others, and feedbacks across scales can occur (Turner et al. 1995). Although the three studies presented are local, the inter-scale complexity will be addressed by up-scaling and down-scaling to capture processes and interactions at higher (county, region, globe) and lower (household, personal) levels, when needed.

The selected chronologies depart from a rural reality that is progressively transformed into an urban one with completely different functions within the BMR, namely residential, leisure, transport infrastructures, and nature conservation. In chapter 3 the initial year of the temporal framework (1924-2008) was chosen because it seemed back enough to explain the process of depopulation which effects on land-cover were to be

analyzed by comparing aerial photographs from 1956 and 2002 in a Geographic Information system. Meteorological data was obtained from the station with the longest and most complete series available in Montnegre-Corredor mountains, starting from 1977 (Collsacreu). The last year to be included in the meteorological series was 2007 because the work was done in 2008 and complete years were needed. The closing year of the chronology is 2008 since it was the year of the last field surveys. The forest model GOTILWA+ was used to simulate the water runoff from the catchment given the lack of measured data.

In chapter 4, the beginning of the temporal framework was set back to the 18th century since it is when the Catalan agricultural systems enter the path of specialization in several cash crops after the subsistence-oriented agriculture of the previous century (Fontana 1990), a very relevant fact to answer the questions regarding the integration of local productive systems in regional and national markets. Strictly speaking, the analysis starts in 1777, which is the year of the oldest document that we used (see note 6 from chapter 4). The information provided by a wide and detailed archival record was integrated with the qualitative content analysis of 20 semi-structured interviews, as well as with the data gathered in the field work of the last five years and in the Ecological Monitoring Scheme of the Montnegre-Corredor Park.

The chronology of chapter 5 starts in 1885, year of the oldest document quoted (see note 4 from chapter 5), although the archival survey focuses in the period 1919-1979. As in the previous chapter, the information from 17 semi-structured interviews was integrated with the archival information in a particular narrative. In this case, though, the interest was more on the experiences of the interviewees (life stories) rather than on the management of natural resources.

In the three case studies, and in a similar way to the spatial scale, the analysis moves back beyond the starting point of the chronology to explain events that are important to understand the processes happening in the temporal framework under study. This is the case of the origin of the settlement in dispersed farmhouses in Montnegre mountains, which may be dated back to the end of the first millennium (Section 4.3), or the origin of the new town of Matadepera, which started to be build in 1768 (Section 5.3.1).

Real world situations are empirically analyzed by means of an integrative methodology that has evolved with the place and with the time spent in the study of it. From a proper understanding of empirical facts, and when possible, a contribution to theoretical debates or to current knowledge of specific issues is made.

3. LOSS OF WATER AVAILABILITY AND STREAM BIODIVERSITY UNDER LAND ABANDONMENT AND CLIMATE CHANGE IN A MEDITERRANEAN CATCHMENT (OLZINELLES VALLEY)[1]

Abstract

In the north rim of the Mediterranean region, where forest cover is increasing as a result of land abandonment and temperatures are rising as a result of climate change, there is increasing interest for the effects of such changes on the runoff of water courses. This is a paramount issue for the conservation of many freshwater habitats and species. In this chapter the effects of both an increase in forest cover after depopulation and land abandonment and an increase in temperature on the runoff of a Mediterranean catchment and on the aquatic and semi-aquatic fauna species of Olzinelles stream were studied. Although in the simulation no decreasing trend in runoff is detected, the monthly runoff-rainfall ratio is now 15% lower than thirty years ago, a fact that may be attributed to a drier period rather than to the small afforestation experienced by the catchment in the last decades. Other factors such as increasing temperatures, changing rainfall patterns and increasing canopy cover may be involved. The observed decrease in the water flow has caused the disappearance of white-clawed crayfish (*Austropotamobius pallipes*), Mediterranean barbel (*Barbus meridionalis*), chub (*Squalius cephalus*), European eel (*Anguilla anguilla*), and southern water vole (*Arvicola sapidus*). The results suggest that in a progressively warmer climate, and especially after land abandonment processes, management of Mediterranean mountain areas should be oriented towards an optimal distribution of agrarian and forest land-covers in terms of water availability. Down to the stream scale, the pools that keep water throughout the year should be conserved and extended to enhance its potential to maintain aquatic and semi-aquatic species populations.

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3.1. Introduction

Global biodiversity is changing at an unprecedented rate as a consequence of several human-induced changes in the global environment, such as land-use change and climate change (Hassan et al. (ed) 2005; Vitousek et al. 1997). Land-use change has caused declines in biodiversity through the loss, modification, and fragmentation of habitats; degradation of soil and water; and overexploitation of native species (Foley et al. 2005). Habitat destruction is, in fact, the leading cause of species extinction (Pimm and Raven 2000). With respect to climate change, only 40 years of warmer temperatures have affected the phenology and the distribution of species of a wide range of taxonomic groups across the globe (reviews in Parmesan and Yohe 2003; Peñuelas and Filella 2001; Root et al. 2003; Walther et al. 2002). As some of these works point out, climate change may lead to a decoupling of species interactions and pose a serious threat to the conservation of biodiversity around the world. Although there is ample evidence of the effects of land-use change and climate change on biodiversity at a global scale, the strength of interactions among these drivers in their effects on biodiversity is virtually unknown (Sala et al. 2000), specially at regional and local scales.

Mediterranean ecosystems may experience large biodiversity loss because of their sensitivity to all drivers of biodiversity change, particularly land-use change (Sala et al. 2000). Land-use patterns in the Mediterranean Basin are rapidly changing, mainly in two opposite directions for the north and the south rim: a fast increase in firewood extraction, overgrazing, encroachment of agriculture, and regression of forest in the south; and land abandonment with young, poorly managed and fuel-accumulating forests in the north (Puigdefábregas and Mendizábal 1998; Terradas 1999). Although forest recoveries offer some important environmental services, such as carbon sequestration and soil conservation (Rudel et al. 2005), it is known that land abandonment and afforestation may lead to a loss of landscape heterogeneity and have negative repercussions for biodiversity (Atauri and de Lucio 2001), e.g. open habitat bird species (Preiss et al. 1997). Moreover, the establishment of forest cover on sparsely vegetated land or on grasslands decreases water yield from the catchment (Bosch and Hewlett 1982; Gallart and Llorens 2003; Jackson et al. 2005). The decrease in water yield caused by the increase in the forest cover of the catchment is added to that associated to climate variability (Gallart and Llorens 2004).

In the Catalan region, forested area has increased in the last century (MMA 2005) as a result of land abandonment, spontaneous regeneration and afforestation works. Temperature has increased by ca. 1 ºC in the last fifty years; potential evapotranspiration has increased 13 mm per decade during the period 1910-1994, while precipitation has not significantly changed (Peñuelas et al. 2002; Piñol et al. 1998). Thus, the hydrological cycle may be affected by an interaction between the increased vegetated land cover and the increased aridity.

This chapter evaluates whether this interaction can be related to changes in catchment runoff and stream biodiversity. For this purpose, the Mediterranean catchment of Olzinelles valley was selected. In Olzinelles valley, a strong rural exodus during the twentieth century has decreased the extension of land under cultivation, favoring a forest cover expansion through spontaneous growth or plantation. Forest exploitation to obtain firewood and charcoal has been reduced due to the substitution of forest fuels by fossil fuels in the 1960s, and as a consequence forest fuel and canopy cover have increased. According to the available meteorological data from Montseny mountains, average annual temperatures in the region have increased 1.2-1.4 ºC since 1950 while the total amount of annual precipitation remained unchanged (Peñuelas and Boada 2003). It was hypothesized that these land-use and climate changes may have caused a decrease in the water runoff in the Olzinelles stream and a decline of its biodiversity. To test such hypothesis, we (i) studied the rural exodus (1924-2007), (ii) conducted a land-cover change analysis with a Geographic Information System (1956-2002), (iii) studied the climate trends for the study area (1977-2007), (iv) modeled hydrological changes using the forest growth simulation model GOTILWA+; and (v) documented the presence or absence in different historical moments of those fauna species with aquatic or semi-aquatic requirements, by conducting surveys in the stream, by monitoring old surveys and by conducting interviews to local inhabitants.

3.2. Materials and methods

3.2.1. Study site

Olzinelles valley has an area of 827.6 hectares (Fig. 1). It is located in Montnegre mountains, which are part of the Catalan coastal range, in the Mediterranean region. The

mean annual temperature is 14.6 ºC and the average annual rainfall is 703 mm (calculated over the last 30 years). The relief is structured in low hills (the highest reaching 558 m a.s.l.) and short streams that have formed small valleys by eroding the granitic base. At present, all the streams have an irregular regime, but the main one, named Olzinelles, used to have a permanent flow, as well as the other streams of the north face of Montnegre mountains that flow into the Tordera River (Montserrat 1989; Otero et al. 2007a). Almost all the study area is covered by forest, mainly cork oak (*Quercus suber*) forest and holm oak (*Quercus ilex*) forest. There are also European alder (*Alnus glutinosa*) forests along Olzinelles stream, which present a high mortality of trees due to the recent reduction in runoff (in the field work up to 91 dead alders were counted, which means about 2 dead alders each 100 m, only in the immediate stream bed), and some monospecific plantations of *Platanus* sp. and *Pinus pinaster*. Crop fields and abandoned fields (from know on, fields) account for 3% of the valley. All the population of the valley (20 inhabitants) lives in scattered *masos*, the traditional farmhouses of the Catalan countryside. Land tenure is private in all the area and 84% of it is included in the Montnegre-Corredor Park since 1989. The valley used to belong to the municipality of Olzinelles, and since 1927 it belongs to the municipality of Sant Celoni.

3.2.2. Demographic data

Demographic data were provided by the Olzinelles and Sant Celoni municipality censuses (1924, 1936, 1970, 2007) and Olzinelles Parish censuses (1943, 1956, 2000), located in the City Archives of Sant Celoni and the Parish Archives of Olzinelles. A database including name and surname, year and place of birth, marital status and number of children, main economic activity and other additional information of inhabitants was created.

3.2.3. Cartographic sources and GIS analysis

Aerial photographs of 1956 (US Army, scale 1:30,000) and orthophotos of 2002 (Institut Cartogràfic de Catalunya, scale 1:5,000) were obtained. By means of photointerpretation in the Geographic Information System MiraMon (Pons 2004) and field work land-cover maps of both years were created, including the following land-

cover types: forest, fields, plantations of plane trees and poplars, shrubland, houses and bare soil. Land-cover change between 1956 and 2002 was studied by overlapping both maps in the GIS.

3.2.4. Meteorological data

Meteorological data (temperature and precipitation) from the period 1977-2007 were provided by the meteorological station of Collsacreu (located near the study area, at 395 m a.s.l., fig. 1). Linear regression of average annual and monthly temperature and rainfall versus the years were calculated. Trends in temperature and rainfall were evaluated using a non-parametric Kendall Tau test. Linear regression of number of days with rainfall was calculated at a yearly basis. To evaluate the changes in rainfall patterns the recorded daily precipitation were classified in 5 intervals (<1.0 mm, 1.0-9.9 mm, 10.0-29.9 mm, 30.0-49.9 mm, and ≥50 mm) and tested whether there were significant changes in their frequency between the period 1977-1991 and 1992-2007 (one factor ANOVA for each interval). All statistical analyses were conducted using STATISTICA version 6.0 for Windows (StatSoft, Inc. Tulsa, OK, USA).

3.2.5. Hydrological modeling: GOTILWA+

In order to assess the effect of land-use change and climate change on water runoff of Olzinelles stream, a simulation test using GOTILWA+ forest model was performed. GOTILWA+ (Gracia et al. 1999; Gracia et al. 2005) is a process-based model that allows the performance of simulations of water use by forest under changing environmental conditions. The data of temperature and rainfall from the Collsacreu meteorological station (1977-2007), available at a monthly basis, were transformed to daily values by means of a Markovian matrix derived from a series of daily data from the same station (available from 20/11/2000 to 31/12/2007). Data on forest structure and composition was obtained from the Third National Forest Inventory, conducted throughout Catalonia in 2000-2001 by the Spanish Ministry of the Environment and the Centre for Ecological Research and Forestry Applications of the Autonomous University of Barcelona. Seven simulation units that corresponded to different subcatchments of Olzinelles valley were defined. For each subcatchment the data of the inventory station located inside of it were used, which included information by tree

species about volume and biomass, stand structure and ecological variables. No forest management was assumed. For the case of fields and shrublands, a standard vegetation structure was used in all the catchment. With these vegetation and meteorological data we ran the model and aggregated the outputs of annual/monthly runoff at catchment level taking into account the land-cover areas obtained by the photointerpretation and a constant rate of annual/monthly land-cover change inferred from the GIS analysis. Land-cover types were grouped in two categories: (1) forests (forest and plantation of plane trees and poplars), and (2) fields and shrublands. The rainfall received by houses and surroundings was considered to be retained without reaching the stream. Bare soil was not considered in the water balance since it represented less than 0.2% of the catchment area. To test whether the model outputs were realistic they were compared to the data gathered by different authors in Fuirosos stream, located at about 6 km NE from Olzinelles catchment. Trends in annual runoff were evaluated using a non-parametric Kendall Tau test. Linear regressions of monthly runoff versus monthly precipitation in two different periods were calculated. All statistical analyses were conducted using STATISTICA version 6.0 for Windows (StatSoft, Inc. Tulsa, OK, USA).

3.2.6. Fauna information

We documented the presence or absence during the last decades of five species with aquatic or semi-aquatic requirements: freshwater white-clawed crayfish (*Austropotamobius pallipes*), Mediterranean barbel (*Barbus meridionalis*), chub (*Squalius cephalus*), European eel (*Anguilla anguilla*), and southern water vole (*Arvicola sapidus*). To do so, old surveys conducted by Martí Boada during thirty years of field work were reviewed, as well as some reports of the Ecological Monitoring Scheme of the Montnegre-Corredor Park. A sample of the stream was conducted in order to confirm the absence of the fauna (June-July 2008). The sampling consisted in walking upriver along the entire stream bed, which was divided in three stretches to be sampled during one day each (the length of the stream is about 5 km), and checking exhaustively the presence of the five species. We looked especially in the roots of alders (*Alnus glutinosa*) and in the holes of the submerged rocks, where crayfishes and water voles could be captured thirty years ago. For the case of water vole, special attention was paid in finding the particular galleries that they excavate in the slopes of the stream.

For the case of the crayfish, the absence of the species was compared with the data by GESMED (2008), who sampled the stream using a species-specific method. Likewise, for the case of the fish species, the data by Aparicio et al. (1997) and URS (2007), obtained by means of systematic electrofishing surveys, was used. Moreover, a sample of 11 people that used to live, work, fish or hunt in the valley were interviewed. Interviews were recorded with a digital recorder, introduced to the PC and transcribed.

3.3. Results

3.3.1. Depopulation

Fig. 2 shows the evolution of population in Olzinelles valley, where a clear process of rural depopulation took place. The 84 inhabitants of 1924 decreased to 20 in 2007, meaning a loss of 76% of the population in 83 years. The highest depopulation rates were found between 1924 and 1943, while during the period 1943-2000 the depopulation rates were lower. The number of inhabitants per house greatly decreased in the period 1924-1943 (10.5 to 4.9 people per house), and reached its minimum in year 2000, with 1.8 people per house. In the last 7 years, however, there was an increase in the population and in the number of inhabited houses. Between 1924 and 1970 there was a significant decrease in the number of farmers: 21 in 1924, 13 in 1936, and 7 in 1970 (the censuses registered only males as farmers, while women were registered as house workers even if they worked as farmers too). Other land managers such as estate owners and administrators also dropped: 4 in 1924, 5 in 1936, and 1 in 1970.

3.3.2. Decrease in agrarian cover and increase in forest cover

Depopulation and land abandonment favored a loss of agrarian cover and an increase in forest cover, as seen in table 1. Forest cover increased 19.5 ha (2.4% of the total catchment area), agrarian cover decreased 36.1 ha (4.4% of the total area), and plantations of plane trees and poplars increased 15.3 ha (1.8% of the total area). As shown in fig. 3, only about a third part of the agrarian cover of 1956 was conserved (37%), while almost half of it was converted to forest, either by spontaneous growth or by coniferous plantation. In 9.4% of the former fields, owners decided to plant plane trees or poplars and in 3.3% of them spontaneous growth of shrubs took place. Another

observed land-cover change is an increase in forest fuel and canopy cover. Fig. 4 shows some graphic examples of these land-cover changes.

3.3.3. Warming in the last decades

The data gathered at Collsacreu meteorological station shows an increase of 0.75 ºC in mean annual temperature between 1977 and 2007 (calculated from the linear regression of the temperature change throughout this period, fig. 5). Mean temperature increased in April (1.65 ºC), May (2.89 ºC) and June (3.07 ºC) ($p<0.001$ in the three months), while no significant trends were found in the other months. According to the meteorological data from the nearby Montseny mountains (10 km), the main increase of the last 50 years occurred in this period (Peñuelas and Boada 2003; Jump et al. 2006a), as it also has occurred in the whole planet (IPCC 2007b). The analysis did not reveal any significant trend in annual rainfall (Fig. 5), although September showed an increase of 57.7 mm ($p=0.01$). Therefore, the increased temperatures and consequent increased potential evapotranspiration rates have conducted to progressively more arid conditions in the area. The number of days with rainfall decreased by 36 (calculated from the linear regression of the number of recorded days with rainfall throughout this period $y=-1.20x + 2512$, $r=0.63$, $p<0.001$). The second period (1992-2007) had on average 11 days less of low rainfall (<1.0 mm) than the first one (1977-1991), the differences being statistically significant at the $p<0.001$ level. The other rainfall intervals didn't show significant changes between periods.

3.3.4. Trends in runoff and runoff-rainfall ratio

No significant trend in runoff was detected for the period 1977-2007 (Fig. 6). Annual runoff was well correlated with rainfall ($r=0.94$) and thus showed a high variability, ranging from 0.74 to 4.88 $hm^3 y^{-1}$. However, the monthly runoff response to rainfall was lower in the second half of the period relative to the first one (Fig. 7). While in the period 1977-1991 the runoff-rainfall ratio (RR) was 0.82 (95% C.I. 0.77-0.87) in the period 1992-2007 it was 0.70 (95% C.I. 0.64-0.75), that is 15% lower. When not considering the changes in land-cover in the catchment area, the RR and C.I. values remained the same. The difference between monthly runoff depth and monthly precipitation increased with increasing values of rainfall, i.e. in high rainfall episodes

there were lower runoffs in the latter period. The two regression lines intercepted at a rainfall value of 48.5 mm i.e. close the mean monthly rainfall of the whole period (58.6 mm).

3.3.5. Loss of fauna species

White-clawed crayfish (*Austropotamobius pallipes*), Mediterranean barbel (*Barbus meridionalis*), chub (*Squalius cephalus*), European eel (*Anguilla anguilla*), and southern water vole (*Arvicola sapidus*) were still present in Olzinelles stream in 1980 (Otero 2006; Boada 1990 -*A. pallipes* wrongly cited as *Astacus fluviatilis*). The origin of the white-clawed crayfish in Olzinelles stream is a translocation of individuals from the Soria province by one of the land owners of the valley by the end of 19th century (Piqueras 2009). The species was still in Olzinelles stream until, at least, 1991, although it was becoming a rare species in the area (Boada 2000 -wrongly cited as *Astacus fluviatilis*) and it hasn't been found in our last survey (June-July 2008), nor in that of 2007 (GESMED 2008). Mediterranean barbel and European eel remained at least until 1991 in two small pools in the central part of the stream (Boada 2000), even though it had already lost the permanent flow. From then on, the only fish species seen in the stream is an isolated individual of European eel found in 1997 after going upriver from the Tordera, the main river where Olzinelles stream flows (Aparicio et al. 1997; Aparicio et al. 2001). The last survey, carried out in the same four sampling stations than in 1997, found no fish species (URS 2007). Three introduced fish species have been found in artificial ponds of the valley: rudd (*Scardinius erythrophthalmus*), common carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) (Boada 2000; Otero 2006). With respect to southern water vole, a semi-aquatic rodent, the last one sawn in Olzinelles stream dates back to the beginning of the eighties (observation of Martí Boada). The sampling in 2008 ruled out the presence of the water vole due to the absence of water in the stream and trails in the riverside.

Finally, some of the interviewed people gave evidence of the existence and use of some of this species in the past decades. As an example, Sadurní M.V., hunter and fisher of the Montnegre mountains born in 1926, used to fish crayfish in Olzinelles stream. Sometimes the fishers were bitten by a water vole, since the holes of both species, located under the roots of alders, often coincided. After the fishing, in some occasion

they cooked rice with the crayfish and some eels captured in Olzinelles stream. Water vole also used to be captured and eaten by local people in Olzinelles and in Tordera basin.

3.4. Discussion

3.4.1. Depopulation and land-use changes

The decrease of population found in Olzinelles valley between 1924 and 2000 was related to the removal of people to near villages searching for better paying non-farm jobs and better life conditions. This was the case of Sant Celoni village, where a local industry based on textiles, cork, wood and milk was developing since the arrival of the railway in 1860 and the electricity in 1909 (Abril and Portals 2005; see chapter 4). The recovery of population in Olzinelles after 2000 may be related to the restoration of *masos* by urban people that wish to move from cities or villages to the countryside.

The agrarian area that remained in 2002, mainly located in the valley bottom, consists of flat fields where mechanization can be easily implemented. However, as the sharecroppers left their lands and the agrarian products lost profitability, some flat fields in the valley bottom were totally converted to plantations of plane trees (*Platanus* sp.), poplars (*Populus nigra*), maritime pines (*Pinus pinaster*) or radiata pines (*Pinus radiata*), fast growing trees planted by the land owners to be sold as wood. The steepest fields, mainly located in the northern part of the study area, have been either spontaneously colonized by oaks or converted to pine plantations. Unlike the rest of the valley, which is mainly occupied by 4 large estates with extensions ranging from 78 ha to 386 ha (meaning 90% of the valley), this area consists of numerous small plots that were mainly used as vineyards to produce small amounts of wine for self-supply. The abandonment of the vineyards (1950s-1970s) was related to changes in life style brought about by the industrialization of the area and to the new interest of the small land owners to plant fast growing trees in their plots (Baylina et al. 2006).

The expansion of forested cover detected between 1956 and 2002 represents only about 4.2% of the valley, considering forest and plantation of plane trees and poplars together (Table 1). However, the fact that the increase in forest cover took place with relatively

low depopulation rates (Fig. 2) suggests that in the previous decades, when higher depopulation rates prevailed (1924-1943), the valley experienced a greater increase in forest cover. In fact, the maximum agricultural expansion in the Vallès County and in other Catalan counties dates back to the second third of the 19th century, when phylloxera plague hit French vineyards, causing Catalan wine relative prices to soar and inducing a new wave of vineyard plantation (Cussó et al. 2006), often in previously deforested plots.

With respect to changes in forest use, during the 1960s fossil fuels started being widely used in the region, and forest fuels lost market value. As a consequence, coppicing for firewood and charcoal, as well as shrub clearing to obtain thin firewood, decreased markedly in Montnegre mountains. An analysis of the evolution of firewood felling in Olzinelles, studied by means of the permissions and the registers of the forest administration for the period 1956-2004, shows a sharp decline in 1964, mainly explained by the decrease in the appropriation of cork oak firewood. It is also observed that from 1962 the permissions do not register anymore the clearing of shrubs (Otero et al. 2008).

The depopulation and land-use changes that have taken place in Olzinelles valley constitute a paradigmatic example of what has occurred in Catalonia and Spain, as well as in many other regions of Europe and the Earth. In the case of Catalonia, the industrialization was strengthened in the second half of the nineteenth century (Garrabou et al. 2001), prompting a process of rural exodus and a concentration of population in the urban area of Barcelona since, at least, 1860. Between 1860 and 1970, Catalan rural population decreased from 788,120 (47% of the total population) to 686,994 (13%), and between 1877 and 1970 the share of agrarian working population dropped from 58% to 8% (Vidal 1979). This process particularly affected small peasant towns and isolated houses (*masos*), especially in mountainous areas, where people tended to migrate to the plains and to the main villages. This is observed in the Catalan Pyrenees, where the abandonment of some of the hill slopes that were terraced for cultivation has promoted spontaneous afforestation (Gallart et al. 1997; Poyatos et al. 2005).

In the case of the Spanish mountains, after centuries of intense demographic pressure on the hillsides, there has also been a process of desertion particularly swift since 1940, related to the great losses of population and to the impossibility of mechanization in a large area of farmland (Ruiz-Flaño et al. 1992). Several cases have been described in the Pyrenees, where a loss in the number of inhabitants in the mountain areas, an aging of the population, and a migration to the main cities of northern Spain have taken place in recent decades (Ruiz-Flaño et al. 1992; García-Ruiz et al. 1995; Molinillo et al. 1997). In a similar process than the one described for Olzinelles, the cultivation of cereals on steep slopes became uneconomic and many fields were abandoned, in such a manner that only the valley bottoms and perched flats remain cultivated (Molinillo et al. 1997; López-Moreno et al. 2006). Other mountainous areas of Spain have also experienced rural depopulation and forest expansion, as the Soria province, the one which has undergone the longest and most intense process of rural exodus from the sixties (Paniagua 2008), favoring the growth of forest areas to the detriment of agriculture (Pérez and Fernández 2006).

3.4.2. Trends in runoff and runoff-rainfall ratio

The water runoff simulated by GOTILWA+ model turned out to be realistic. The runoff outputs were compared with the data measured by different authors in Fuirosos (Bernal and Sabater 2008; Acuña et al. 2007; Bernal et al. 2006; Sabater et al. 2008), a very similar stream located at about 6 km NE from Olzinelles. Both streams flow N-NO from the Montnegre hills towards the Tordera River, have comparable catchment areas (O: 8.3 km^2; F: 10.5 km^2), altitudinal gradients (O: 125-558 m; F: 95-773 m), mean annual temperature and rainfall for the period 1997-2003 (O: 15.1 ºC, 675.7 mm; F: 13.8 ºC, 709.6 mm), share of forested and agrarian cover (O: 96%, 3%; F: 98%, 2%), vegetation, land-use history and settlement pattern. The measured average discharge in Fuirosos from January 2001 to July 2002 (Sabater et al. 2008) was 1.7 times higher than the simulated average discharge in Olzinelles for the same time period (136 L s^{-1} vs. 79 L s^{-1}), the difference being explained by both highest catchment area, highest total rainfall and highest extreme rainfall events in January 2001, April 2002 and May 2002 in Fuirosos. Although these average values include exceptionally high discharge peaks and thus are not representative of the baseflow conditions (which in Fuirosos range from 7 L s^{-1} in spring to 20 L s^{-1} in winter according to Butturini et al. 2002), they show that the

model outputs match with the observed fact that Olzinelles has lower runoff than Fuirosos. Moreover, the average runoff depth in Olzinelles catchment is 320 mm (2.65 hm^3 / 828 ha), which is similar to the value provided by Liquete et al. (2009) for the entire Tordera River basin (258 mm).

Even if the annual runoff did not show a decreasing trend (Fig. 6), the different regression slopes in fig. 7 show that in the last 16 years the monthly runoff response to rainfall was 15% lower than in the first 15 years. These results agree with our own observations on the state of the stream during the last decades indicating that around 1991 the flow of the stream shifted from (almost) permanent to irregular with long periods without runoff (Boada 2000). The significant negative intercepts are consistent with the hydrological processes simulated in the model. The fact that rainfall is not converted into runoff until a certain threshold is reached (ca. 23 mm of monthly rainfall) is explained by rainfall interception of tree canopies and by water storage in the soil, both being considered in GOTILWA+. The intercept values are not significantly different between periods, meaning that the behavior of the system under the threshold value of rainfall has not changed. However, the lower runoff-rainfall ratio (RR) of the last period was not reflected in the absolute trends (Fig. 6) since it occurred mostly under the highest less frequent values of monthly rainfall.

The drier conditions in the second period than in the first one (more years below the mean annual rainfall) are one of the factors accounting for the decrease in RR. During drier periods the internal water storage capacities of watersheds, mainly related to surface-near ground waters, are depleted and more water infiltrates into the grounds, thus reducing RR. This has been proven to happen in the Fuirosos stream, where the high hydraulic conductivity in the stream edge zone favors the rapid stream water infiltration in the surrounding riparian area regulating the stream runoff generation during the dry and the stream discharge periods (Butturini et al. 2002). The change in the rainfall pattern detected for our catchment should also be taken into account, since the timing and intensity of rainfall have a strong effect on interception loss by canopies (Muzylo et al. 2009). In their study of the interception processes at the event scale in a Mediterranean forest patch, Llorens et al. (1997) describe one particular interception process with a very high interception rate (49%), occurring under dry atmospheric conditions and during low intensity events when active re-evaporation from the

canopies happens even during rainfall. Although as these authors show data obtained at the daily scale cannot be directly transferred to the event scale, the reported decrease in the number of days with low rainfall suggests that in our catchment the relative interception may be lower in the second period in comparison to the first one. However, increased evaporative demand and water loss by transpiration throughout the catchment due to higher temperatures could be offsetting this effect. The warming was especially intense in April, May and June, with increases in mean temperature ranging from 1.65 to 3.07 ºC. The fact that these are the first three months after the leaf unfolding of the main deciduous species in the riverside (*Alnus glutinosa*, *Corylus avellana*, *Platanus* sp., *Robinia pseudoacacia*, *Castanea sativa*, *Prunus avium* and *Ulmus minor*), and that these species have advanced the leaf unfolding more than two weeks in the last five decades as a consequence of warming (Peñuelas et al. 2002) may be influencing the RR due to increased evapotranspiration, although these species are not included in our simulation since they represent a very low share of the catchment area.

As noted in the results section, the RR values were the same regardless of whether the afforestation of the catchment area was considered or not in the simulation. Thus afforestation does not seem to have influenced the RR. The increase in forested area, which represented 4.2% of the catchment, was probably too small to have a significant impact on water runoff, though during the first half of the 20th century, when higher afforestation rates occurred, the effect on water runoff might have been visible. In any case, the variation of vegetation structure should also be considered, since it has a strong influence on interception losses. A review by Llorens and Domingo (2007) found that there was a clear reduction in relative throughfall with increasing DBH, age, height, basal area and LAI, in other words with greater maturity of the stands and canopy closures. Although throughfall increases after thinning, it is not clear whether this leads to higher runoff. Whilst in more humid regions it is suggested that forest harvest contributes to increased peak flows, in Mediterranean forests, i.e. holm oak forests, the increased throughfall after thinning is transpired by the remaining trees at an increased individual rate (Gracia et al. 1999), without becoming stream flow. However, the throughfall increase after thinning is not proportional to the amount of biomass removed or to the increase in between-tree spacing (Llorens and Domingo 2007), and the limit of the assumption that the overall evaporation reduces linearly in proportion to the canopy cover has to be evaluated (Muzylo et al. 2009). According to both reviews, more effort

to model the interception process in very sparse forests and isolated trees should be made, and rainfall partitioning by trees and shrubs into throughfall and stemflow should be studied in more detail, especially in the rainfall range between 600 and 800 mm per year and in several species of *Quercus*. Olzinelles catchment is mainly covered by evergreen *Quercus* forests, receives about 700 mm of annual rainfall and used to have sparse forests when firewood harvesting and charcoal making were the main economic activities of farmhouses, so its dynamics of rainfall interception and partitioning fall within the gap of knowledge identified by these reviews.

The assumption of no forest management in the simulation is consistent with the decreasing trend in firewood appropriation and the biomass accumulation of the last five decades in Olzinelles. Visual comparison of aerial photographs throughout the catchment confirms that canopy cover has greatly increased (Fig. 4) as coppicing of oaks and slashing of ground vegetation decreased dramatically with out migration and land abandonment, as explained in the previous section of the discussion. According to a detailed study of management practices (see table 1 in section 4.7) evergreen oak forests were coppiced every 7-10 years to obtain firewood and to make charcoal. Before felling oaks, slashing of ground vegetation was performed to obtain thin firewood, while some understorey species as *Erica arborea* and *Arbutus unedo* were uprooted and the stumps sold to manufacture wood products. Some competitor species were removed from the stands to improve the growth rate of oaks, and pines were pruned to stimulate growth before felling. Pig herds and sheep flocks grazed herbs, stems, shrubs, shoots, roots, lower branches of trees and acorns in the oaks woodland. As a result of the intensive exploitation, forest remained sparser, had less fuel load and a lower canopy cover compared to the current situation. Since the variation of canopy cover was not incorporated in the land-cover classification nor in the hydrological model to test its role on interception, throughfall and runoff generation, it can only be hypothesized that, as the mentioned reviews suggest, the increase in canopy cover experienced in Olzinelles as a result of land abandonment may had a significant effect on water discharge in the catchment. Moreover, some of the shrub species that were periodically removed from the understorey in Olzinelles (e.g. *Arbutus unedo*) are clearly under-represented in rainfall interception and partitioning studies, although they play an important role in water balances (Muzylo et al. 2009; Llorens and Domingo 2007).

The decrease in RR doesn't seem related to other factors. Water extractions for domestic and agrarian use have not increased, since both the population density and the irrigated area have decreased. Moreover, rural depopulation has led to the abandonment of some of the water infrastructures that were constructed and maintained by the inhabitants of Olzinelles in the past. A total of 5 springs and 5 ponds have been found abandoned in the valley, therefore the water appropriation for human use must be lower than in the past, at least in the catchment area itself.

In Mediterranean regions of the north rim land-use has a great influence on runoff generation (Kosmas et al. 1997) and the expansion of forests and shrublands is related to an increase of evapotranspiration and a reduction of total runoff (Puigdefábregas and Mendizábal 1998). In mountainous areas of Spain, for example, several studies from experimental plots conclude that the growth of forest and shrubs on abandoned meadows and fields reduced the water runoff (García-Ruiz et al. 1995; Molinillo et al. 1997; Lasanta et al. 2006). In some cases, afforestation and reforestation processes in the catchments may explain up to one third of the loss of annual discharge of rivers (Beguería et al. 2003; Gallart and Llorens 2004). The increasing use of water by new forests is added to the water used for irrigation and urbanization, and to decreasing rainfall inputs in rivers as important as Ebro (Gallart and Llorens 2004; Gallart and Llorens 2003).

The results presented may serve to clarify some of these conclusions. In Mediterranean mountains historically devoted to forestry and with little agrarian area, as is the case in Olzinelles, the afforestation experienced in the last decades may be too small to have a significant influence in the runoff. Rather, decreases in water flow may be related to drier periods, longer droughts, and increased potential evapotranspiration rates, trends that are expected for the near future (IPCC 2007b). However, the great increase in forest canopies as a result of forestry abandonment, which is a generalized phenomenon in Mediterranean mountains, should be considered in more detail in further studies.

3.4.3. Loss of fauna species

The disappearance of white-clawed crayfish, Mediterranean barbel, chub, European eel, and southern water vole is clearly related to the hydrological changes of the stream. No

other factors seem to account for such disappearance. In Olzinelles valley there are neither industrial nor agrarian sewage that may cause water quality to deteriorate, and in the main river (Tordera) the strong industrial pollution has been reduced in recent years by the construction of sewage treatment plants and other administrative measures (Miralles 2008). These species never had a market value in the study area, and fishing and capturing used to be occasional, so it is not expectable a negative effect in their populations for these reasons. Moreover, the human pressure on these species has surely decreased, taken into account that from 1924 to 2007 the population of the valley has dropped by 76%.

The disappearance of white-clawed crayfish in Olzinelles stream may be easily related to the loss of water flow, but also to the effect of the red swamp crayfish (*Procambarus clarkii*), one of the more widespread invasive species of crayfish in Spain, introduced in some streams of Montnegre mountains by 1989 (Boada 1990). However, in the last surveys in Olzinelles stream *P. clarkii* has not been found, a fact that has been related to the absence of water (own survey 2008 and GESMED 2008).

Mediterranean barbel and chub have good populations in the entire Tordera basin (Benejam et al. 2008), while eel is less abundant due to different factors that make difficult the migration along the main river (Aparicio et al. 2001; Aparicio and Vargas 2004). In the Fuirosos stream, Mediterranean barbel, chub and eel survive in isolated pools during dry periods, showing high spatiotemporal variability in biomass and density according to hydrological conditions (Aparicio et al. 2001; Aparicio and Vargas 2004). This would also be the case of Olzinelles stream until, at least, 1991, when barbel and eel were found in two small pools in the central part of the stream, as noted above. But the average runoff is lower and unlike Fuirosos there are no more pools big enough to maintain stable fish populations, and only some isolated individual may go upriver from the Tordera in months with high water runoff, as the young eel found in 1997 (E. Aparicio, personal communication). The exotic fish species in Olzinelles stream (*Scardinius erythrophthalmus*, *Cyprinus carpio* and *Carassius auratus*) have been found only in artificial ponds, so no negative interactions with native fish species from the stream may be expected.

In the Vallès County, southern water vole declined strongly in the last decades as a consequence of the degradation of aquatic ecosystems (Arrizabalaga and Montagud 1989), and at present it is considered in danger in Tordera basin (Torre et al. 2008). In Olzinelles stream, the last one we saw dates back to the beginning of the eighties (observation of Martí Boada). Similarly to the fish species, the disappearance of the water vole seems related to the changes in the hydrological features of the stream. Although results from a study carried out in southwest Spain suggest that it is adapted to suffer the typical droughts of some Mediterranean areas (Fedriani et al. 2002), in the sampling of 2008 no galleries in the slopes of the stream or trails in the riverside were detected.

3.5. Final remarks

The socioecological changes that have taken place in Olzinelles valley may be considered as representative of Mediterranean mountains that have experienced dramatic depopulation and land abandonment processes under current climate change, especially those mountain areas that have been historically devoted to forestry and were agriculture has been very limited in extent. It could be argued that the reported loss in biodiversity is local and does not have any effect in the conservation status of the species. But some of these species have small distribution areas and their overall population is declining. Mediterranean barbel has been considered as near threatened by the IUCN Red List and listed in the Annexes II and V of the European Union Habitats Directive (Elvira 1995; Crivelli 2006). The white-clawed crayfish is considered a vulnerable species by the IUCN Red List (Sket 1996), and is listed in annexes II and V of the European Union Habitats Directive. Southern water vole, which is only found in the Iberian Peninsula and France (Fedriani et al. 2002; Cubo et al. 2006), is considered of lower risk (near threatened) by the IUCN Red List (Amori 1996).

The results from this chapter suggest that conservation strategies in Mediterranean forests should take into account the use of water by forests and its role in the hydrological balance of the catchment. Management of mountain areas in a progressively warmer climate, and especially after land abandonment, should be oriented towards an optimal distribution of agrarian and forest land-covers that guarantees water availability to maintain the stream and the riverside. However, the

recovery of former agrarian cover in order to partially compensate the effects of climate decreasing the runoff would not have a significant effect on runoff unless large forested areas were converted into fields or pastures, something that must be carefully evaluated in terms of the opportunities and the trade-offs with other ecosystem functions and services. In this sense, the share and distribution of agrarian and forest land-covers should be optimized taking into account the conservation of open habitats and their biodiversity (see chapter 4, table 4), the wildfire hazard, the economic activities of the farmhouses and the cultural dimension of landscapes. Evidences from previous studies (e.g. Gracia et al. 1999) suggest that thinning will result in better water status of the remaining trees, but will not increase the runoff in forested catchments where potential evapotranspiration exceeds precipitation (Piñol et al. 1991). However, the great increase in canopy cover experienced in Olzinelles as a result of unmanaged growth of forests and its potential role in the rainfall interception and partitioning processes should encourage new studies to know whether traditional practices such as coppicing, slashing of ground vegetation and extensive grazing would have a positive effect on runoff. Down to the stream scale, the pools that keep water throughout the year should be conserved and extended to enhance its potential to maintain aquatic and semi-aquatic species populations.

3.6. Figures and tables

Figure 1: Olzinelles valley is located in the county of Vallès Oriental, and it is included in the municipality of Sant Celoni since 1927. Source: own elaboration.

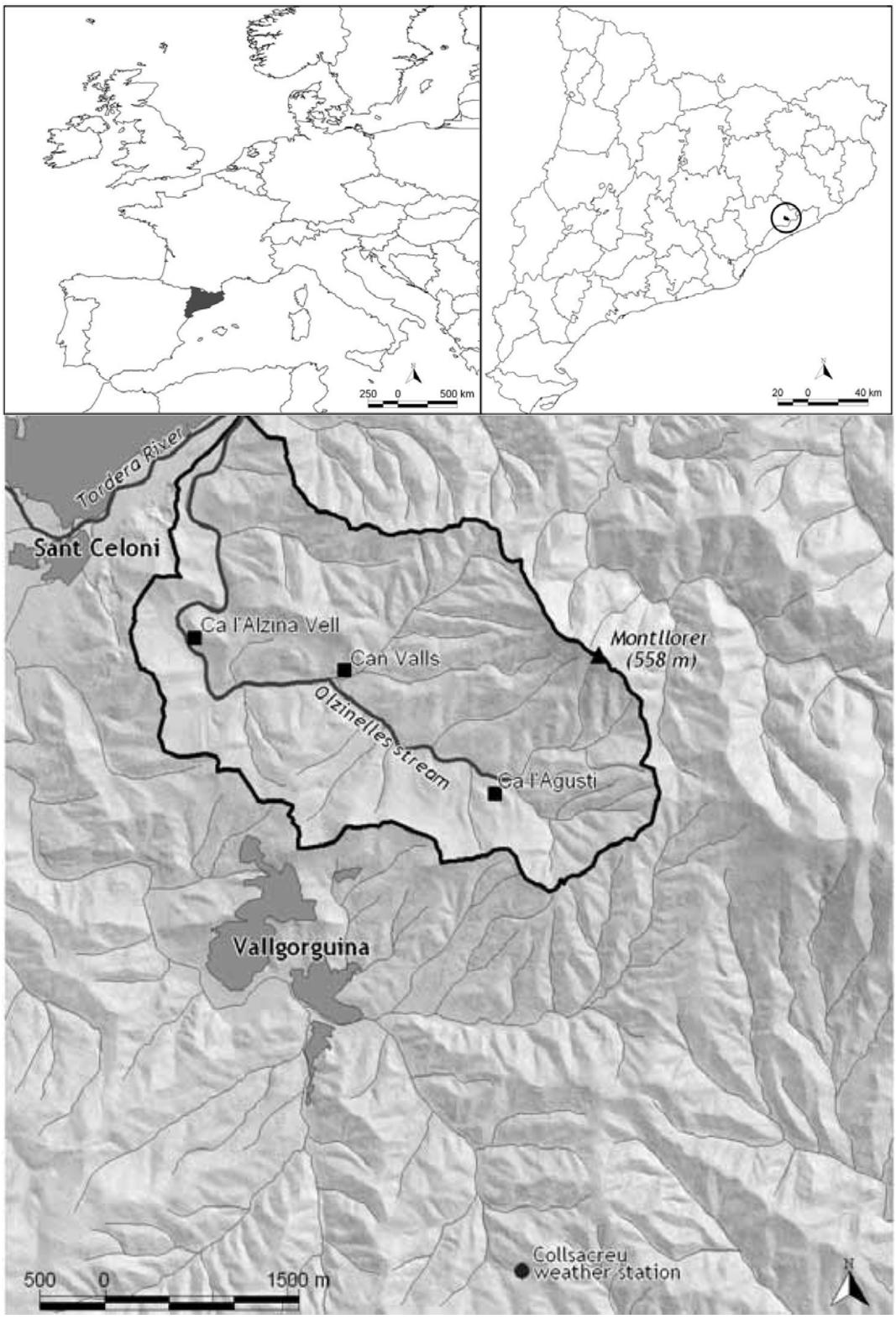


Figure 2: Demographic evolution in Olzinelles valley. Sources: Olzinelles municipality census (1924), Sant Celoni municipality census (1936, 1970, 2007), and Olzinelles Parish census (1943, 1956, 2000). City Archives of Sant Celoni and Parish Archives of Olzinelles.

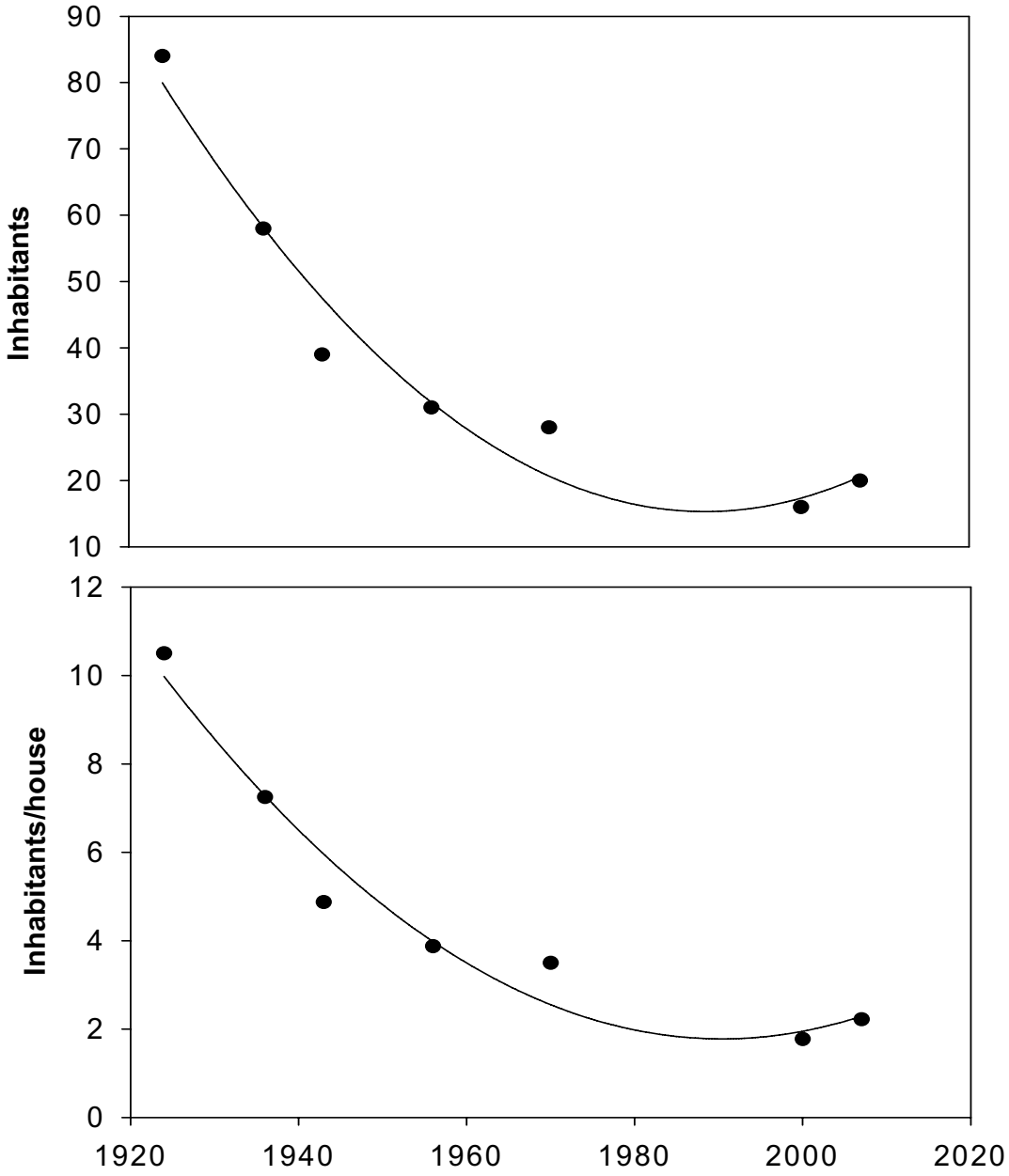
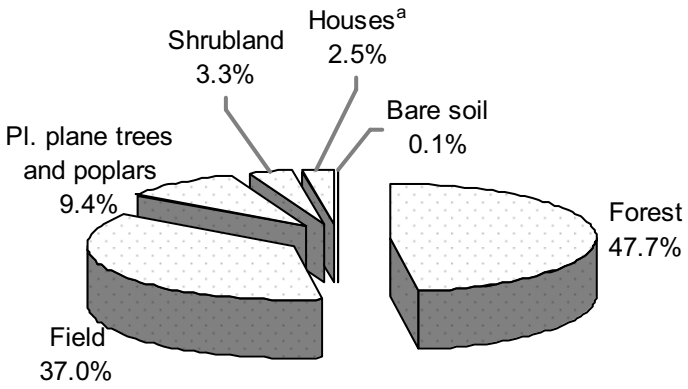


Figure 3: Transformation of agrarian cover between 1956 and 2002. Source: See table 1. Only 37.0% of the 61.5 ha of fields in 1956 has been conserved, while 47.7% has been transformed to forest and 9.4% to plantations of plane trees and poplars.



[a] See note (d) from table 1.

Figure 4: View of Olzinelles valley around Ca l'Agustí in 1956 and 2002. Land-cover changes: 1) Plantation of maritime pines in former fields; 2) Forest densification and increase in canopy cover; 3) Plantation of maritime pines and recovery of holm oak and cork oak in former fields. Source: See table 1.

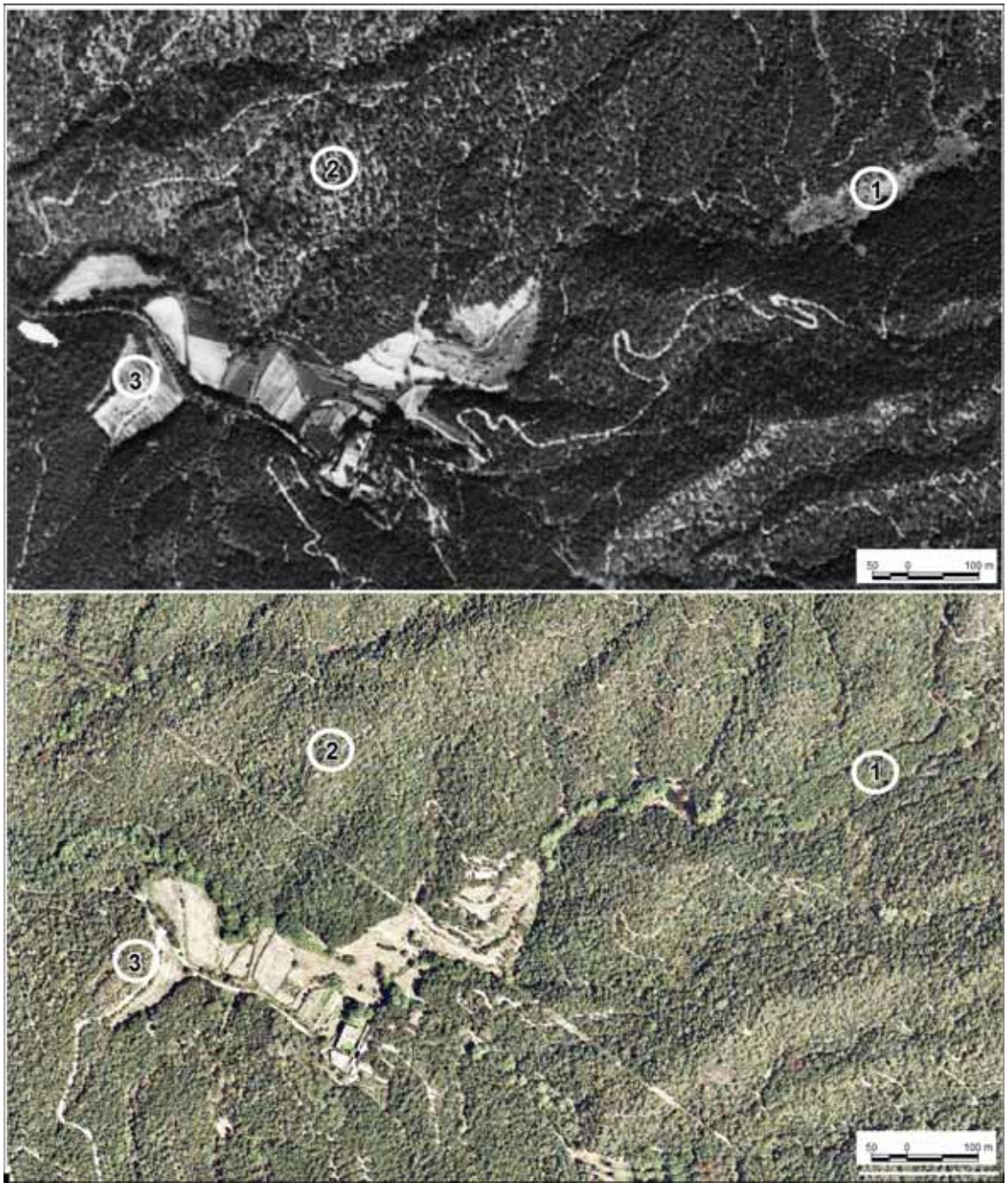


Figure 5: Climate trends in the studied area for the period 1977-2007, measured in Collsacreu meteorological station.

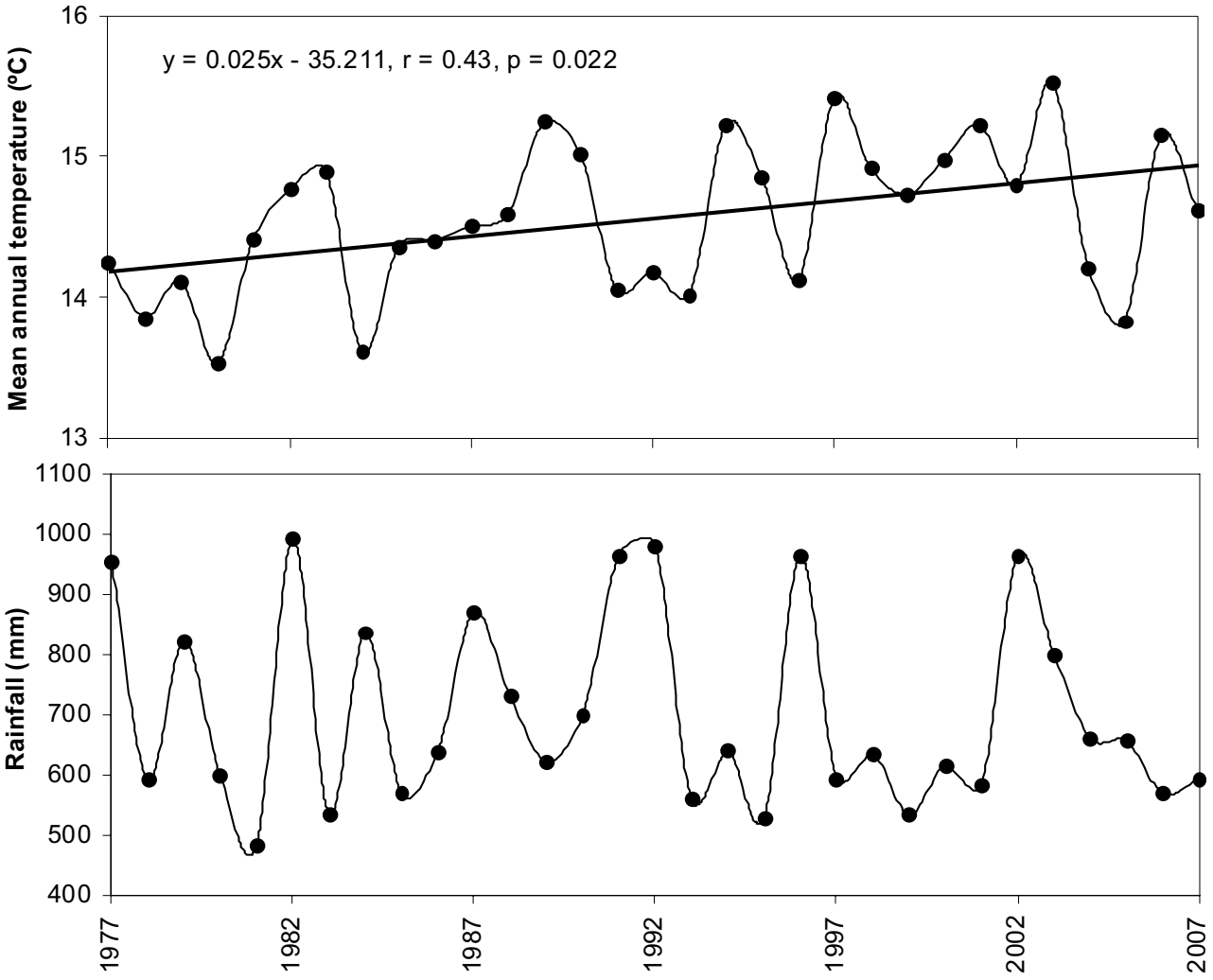


Figure 6: Simulated water runoff of Olzinelles stream for the period 1977-2007.

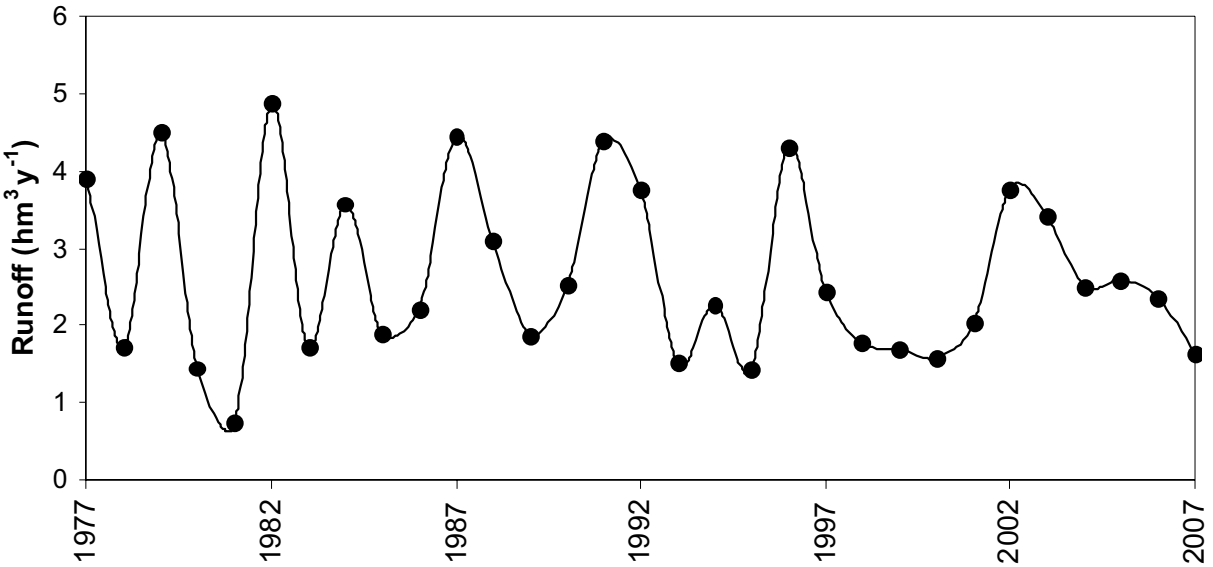


Figure 7: Simulated monthly runoff of Olzinelles stream vs. measured monthly rainfall for the periods 1977-1991 and 1992-2007 considering that land-covers changed at a constant monthly rate inferred from the GIS analysis (see methodological approach in section 3.2).

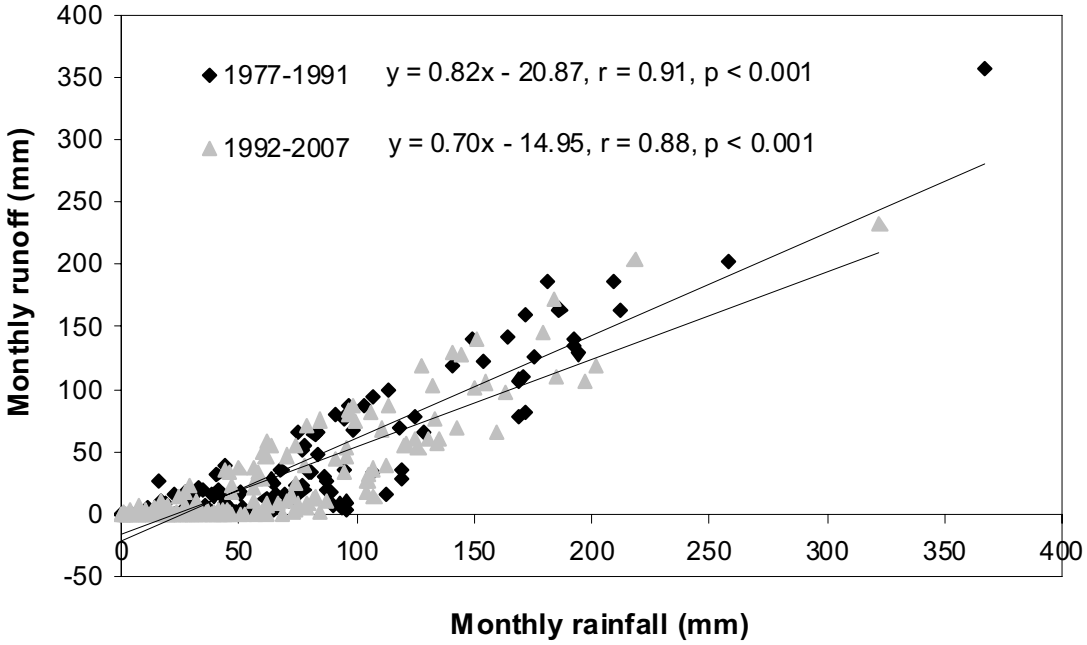


Table 1: Land-cover distribution and change in Olzinelles valley (1956-2002). Percentages relate to the total area of the catchment. Source: Aerial photographs of 1956 (US Army, scale 1:30,000); orthophotos of 2002 (Institut Cartogràfic de Catalunya, scale 1:5,000), GIS analysis and field work.

Land-cover	1956		2002		Δ 1956-2002	
	ha	%	ha	%	ha	%
Forest[a]	751.3	90.8	770.8	93.1	19.5	2.4
Fields[b]	61.5	7.4	25.3	3.1	-36.1	-4.4
Plantation of plane trees and poplars[c]	8.7	1.0	24.0	2.9	15.3	1.8
Shrubland	3.5	0.4	2.3	0.3	-1.2	-0.1
Houses (*masos*)[d]	1.6	0.2	3.9	0.5	2.4	0.3
Bare soil	1.1	0.1	1.3	0.2	0.2	0.0
Total area	827.6	100.0	827.6	100.0	0.0	0.0

[a] Includes all forested area except plantations of plane trees (*Platanus* sp.) and poplars (*Populus* sp.): cork oak forest (*Quercus suber*), holm oak forest (*Quercus ilex*), mixed forest (holm oak and pubescent oak - *Quercus humilis*, holm oak and cork oak, holm oak and pines, cork oak and pines, etc.), riparian forest (*Alnus glutinosa*), coniferous plantations (*Pinus pinaster*, *Pinus radiata*), and chestnut plantations (*Castanea sativa*).

[b] Includes cultivated fields and fields that have been abandoned recently and still cannot be considered as shrubland nor forest. They have been grouped together because they can only be distinguished in the aerial photograph of 2002 but not in that of 1956.

[c] It has been considered a separated category because it was possible to distinguish from the surrounding forest in both aerial photographs (this is not the case of coniferous plantations, which cannot be distinguished properly in none of them).

[d] The increase of 2.4 ha in the area occupied by houses is overestimated, since the less detailed scale of the aerial photograph of 1956 leads to an underestimation of this land cover in this year. No process of urbanization has taken place in the study area, except from the construction of one house in a former barrack hut.

4. SOCIOECOLOGICAL HERITAGE IN MEDITERRANEAN LANDSCAPES. THE CASE OF THE OLD MUNICIPALITY OF OLZINELLES[1]

Abstract

There is growing evidence and recognition that the current global biodiversity decline is closely interrelated to a worldwide loss in cultural diversity, and to a large extent both losses are caused by the same driving forces. This is especially relevant in the Mediterranean, where the maintenance of the richness of life forms is very much related to the presence of traditional practices of resource management. This chapter analyzes the relationship between the abandonment of a diverse set of management practices placed in a specific Mediterranean cultural context and the processes of biodiversity decline in the old municipality of Olzinelles. The approach uses a combination of archival data, semi-structured interviews, extensive field surveys of landscape elements and biodiversity, as well as an exhaustive review of biodiversity monitoring studies in the area. The results show that as a consequence of the loss of a number of diverse agrosilvopastoral practices together with the local exodus and land abandonment many species of plants and animals from fields, meadows and sparse forests are experiencing decreasing trends. To capture the implications of such processes the concept of socioecological heritage is introduced and discussed. Socioecological heritage is understood as a distinctive set of accumulative patterns of socioecological interactions and practices which yield a closely interlinked configuration in both cultural and biological diversities. It is argued that modernization processes that lead to the disappearance of such socioecological heritage do not only affect the biocultural diversity of indigenous groups in developing countries but also such processes can be observed to impinge on other social groups in present industrial societies of the European Union.

[1] This chapter will be submitted to *Ecology and Society*, being the authors Iago Otero, Martí Boada, and Joan David Tàbara. The authors would like to thank the oral sources of the study, and J. Draper, J. Deulofeu, M.T. Monrabà, D. Rangil, C. Stefanescu, Perejaume, M. Borrós, D. Varga, S. Piqueras, G. Rodoreda, L. Sáez, A. Bombí, G. Llimós, and Ó. Sánchez-Camacho.

4.1. Foreword

Josep Travesa, *Pepitu*, was born in 1930 in Can Pau Foguera, one of the smallest farmhouses in the old municipality of Olzinelles where his ancestors lived for generations. The sea breezes from the Mediterranean blew smoothly in the facade of his house, built on the sunny slope of one of the low hills of the Catalan coastal range of Montnegre. Next to his house, Pepitu took care of a subsistence agroforestry system carefully adapted to the regime of a temporal stream: cereals, vines, olive trees, vegetable gardens, fruit trees, holm oaks… His family's livelihood combined extensive dry land farming, livestock raising, and paid work as tree feller and cork peeler for the production of charcoal, firewood, timber and cork in the large forest estates. During his life he witnessed how most of the farmhouses of Olzinelles were abandoned and their tenants migrated to nearby towns and cities searching for better life conditions. His only daughter Aurora also decided to leave Can Pau Foguera as she got married. His wife Assumpció plunged into a severe senile dementia that progressively erased her memory. Pepitu remained the last peasant of Olzinelles to live in a "traditional" way until he died in February 2006. And he did so with an extraordinary fullness and happiness that contrasted with the decadence of the whole universe that was going to disappear with his death. According to the well-known artist and neighbor of Pepitu Perejaume (2006), "the morning when we put his body in the cemetery of Olzinelles, all those landscapes became smaller; lost size, contrast and depth".

4.2. Introduction

It is now widely accepted that the current global biodiversity decline is closely interrelated to a worldwide loss of cultural diversity, and that to a large extent both losses are caused by the same driving forces (Sutherland 2003). The recognition of an "inextricable link" between biological and cultural diversity since the Declaration of Belém[2] has promoted research on the connections between the different dimensions of the diversity of life. Some international organizations, both in the biodiversity conservation area (WWF, UNEP, IUCN) and in that of linguistic and cultural diversity (UNESCO), have noted the significance of such a biocultural perspective and

[2] International Society of Ethnobiology (http://ise.arts.ubc.ca/global_coalition/declaration.php).

incorporated it to a greater or lesser extent in their own approaches and activities (Maffi 2005). In fact, the maintenance of the processes that enhance both cultural and biological diversity is of paramount importance for sustainability, since they are an indispensable source of alternative options upon which new strategies of sustainable management of natural resources may be devised (Tàbara and Giner 2004).

The link between the loss of cultural and biological diversity is especially important in the Mediterranean, where the highly diverse cultural landscapes that resulted from the coevolution between natural and human processes (Farina et al. 2003) are being rapidly degraded due to land abandonment, agricultural intensification, urban sprawl and globalization, generating many negative social and ecological impacts (Farina 2000; MacDonald et al. 2000; Stoate et al. 2001; Catalán et al. 2008). Although the biodiversity decline caused by changing or ceasing management practices has been studied at different levels of biological organization and taxonomic groups (Benton et al. 2003; Atauri and de Lucio 2001; Preiss et al. 1997; Suárez-Seoane et al. 2002, Agnoletti 2007), there is a growing need to understand its relation with processes of cultural impoverishment from an integrated point of view. Moreover, the Mediterranean region offers the opportunity to extend the debates around biocultural diversity from indigenous groups to more varied social groups affected by some degree of modernization along its recent history (Cocks 2006).

Olzinelles is an old municipality located in the second ring of the Barcelona Metropolitan Region (Fig. 1A). A walk across its fields and forests on a working day of Spring would bring the visitor to a world full of bird songs hidden in a lush forest which seems completely unimaginable only 45 minute drive from Barcelona city. However, a strange sensation of emptiness may also invade the viewer: a rural landscape with no peasants, shepherds or forest workers. Olzinelles is an example of extremely depopulated mountainous area of the north rim of the Mediterranean basin. With an extension of 2287 ha, it is located in the north-western side of Montnegre mountains, in the Catalan coastal range. Although with a Mediterranean climate (mean annual temperature is 14.6 ºC and mean annual rainfall is 703 mm, see fig. 5 from section 3.6), some Eurosiberian plant species find an appropriate habitat in Montnegre mountains due to the humidity brought by the marine clouds to the peaks (the highest reaching 767 m a.s.l.) in summer and to the capacity of stream soils to maintain a relatively high

content of water (Montserrat 2007). Settlement has historically been structured in dispersed farmhouses (*masos*) that combined subsistence agriculture based on cereals and vines with the exploitation of evergreen oak forests (*Quercus ilex* and *Q. suber*), the most extensive land cover throughout the last centuries (Otero 2006).

By focusing in the local context of Olzinelles, this chapter analyzes the relationship between the abandonment of a diverse set of agrosilvopastoral practices placed in a specific cultural context and the process of biodiversity decline. An interdisciplinary methodology allowed us to gain a deep understanding of the socioecological dynamics of Olzinelles landscape. First, the Archives of the Crown of Aragon, the National Geographic Institute, the Catalan Cartographic Institute, the regional office of the Catalan Ministry of Agriculture, the City Archives of Sant Celoni[3] and the Parish Archives of Olzinelles, as well as private documents from Olzinelles families, were reviewed. Key documents about land uses, agricultural taxes, demography, economic activities and territory, covering the period 1753-2004, were collected and their content analyzed. Second, interviews were held with 15 individuals born between 1913 and 1960 who lived in a farmhouse and/or worked in rural activities in Olzinelles. The sample of interviewees was balanced in terms of access to land and labor conditions (small, medium and large estate owners, sharecroppers and day laborers) and types of work (agriculture, livestock, forestry and housework). Interviews were semi-structured and combined information about such works (Otero 2006: 190) with the life history of each interviewee so as to capture change of practices over time (Mille 2000). Interviews lasted between half an hour and three hours. They were recorded with a digital recorder and transcribed.[4] Next a content analysis was performed for all interviews, synthesizing the diverse agrosilvopastoral practices and grouping them in land cover types (e.g. cork oak forest), crops, livestock species, housework and water management. The painter and poet Perejaume, who has developed an innovative artistic method to capture landscape "voices" working from his studio in Olzinelles (e.g. Perejaume 1998), was also interviewed. Third, with field work and GIS techniques 267 physical elements of local landscape that help to interpret the interactions between the local community and its

[3] The municipality of Olzinelles was annexed to the municipality of Sant Celoni in 1927 (see section 4.3).
[4] Four additional informants from Olzinelles were supplied by D. Rangil, author of a series of ethnographic works from Montnegre mountains (Rangil 2008, 2009). One additional informant also from Olzinelles was taken from an interview conducted by the Spanish Television in the 1980s. Altogether we worked with 20 informants (12 men and 8 women), which constitutes approximately 10% of the mean rural population of Olzinelles in the 20th century.

environment were catalogued (georeferenced and described): farmhouses, stone terraces, vineyard huts, boundary stones, churches and chapels, springs, ponds, irrigation channels, wells, weirs, bridges, large trees, etc. Finally, evidences of a decline in biodiversity caused by the loss of traditional agrosilvopastoral practices were collected. To do so, the surveys conducted by Martí Boada during more than thirty years of field work in Olzinelles were reviewed, and the data gathered by the Ecological Monitoring Scheme of the Montnegre-Corredor Park, as well as other relevant works conducted by scientists from the region, were exhaustively collected.

Section 4.3 presents the key processes of the environmental history of Olzinelles, focusing in the last three centuries. Section 4.4 analyses the agrosilvopastoral practices of the local community during the 20th century, taking into account the cultural context in which they were placed. Section 4.5 shows the animal and plant species that are experiencing recessive trends in the last decades due to the lack of such practices. Section 4.6 discusses the findings of this chapter in relation to the current debates around biocultural diversity and sustainability, and a definition of *socioecological heritage* is proposed. Socioecological heritage is defined as a distinctive set of accumulative patterns of socioecological interactions and practices which yield a particular configuration in both cultural and biological diversities, and it is used to understand how to deal with wider processes of global environmental change.

4.3. Olzinelles: brief history of the coupled human-environment system

Although Montnegre mountains have been inhabited since pre-Roman times (Abril et al. 1995), the origin of the settlement in dispersed farmhouses (*masos*) may be dated back to, at least, the end of the first millennium (Portals 1998). The life of the new settlers was organized around small mountain parishes such as Sant Esteve d'Olzinelles, referred for the first time in 1083 (Vilageliu 1981). As centuries went by the feudal authorities gained control over the resources and the settlers of the farmhouses in Montnegre, who were subjugated to unfair socioeconomic conditions and even obliged to spend the entire lifetime in the land of the lord (Portals 1998). In a complex and conflictive transition from feudalism to agrarian capitalism, the peasants who held the *masos* gradually gained control of the rights of access to the main resources (Cussó et

al. 2006), with private landownership being totally established as early as in the mid 18th century (Otero 2006).

Under the national demographic growth of the 18th century, new peasants arrived in Montnegre and built their farmhouses (Rangil 2009). Olzinelles recovered from the population loss of the 15th century and increased its inhabitants from 89 to 147 between 1719 and 1787 (Abril et al. 1995). Although most of the agrarian land of the farmhouses in Olzinelles was dedicated to cereals for self-consumption (Otero 2006), the expansion of vineyards reflected already the trend of the Catalan economy towards an increase in cash crops after the subsistence-oriented agriculture of the previous century (Fontana 1990). Vineyards were planted in former forests or cereal fields by landless peasants in plots leased by the landowners through the *rabassa morta* contract[5] (Zaragoza 2006: 99-110). However, the mountainous relief of Olzinelles, with only small flat fields along the main water courses, prevented the landowners from engaging in the wine specialization that was experiencing the coastal area. Most of the productive land was occupied by large expanses of forests. They had a central role in the economy of the largest landowners, who benefited from the integration of forest products in national economies. Forests of the region were subject to state control to guarantee the supply of timber for naval construction. Oaks, pines and poplars were sold to the shipyards of the coast, located at only 4-7 hours distance.[6] They also provided firewood for the wine distilleries of the region, cork to manufacture bottle caps for the French champagne (Nadal and Urteaga 1997, 1998), and charcoal and firewood for the city of Barcelona (Zamora 1973: 390).

The economic importance of Montnegre's forests increased as the process of industrialization in Catalonia strengthened from the second half of the 19th century. The arrival of the railway in the nearby Sant Celoni village in 1860 prompted the development of a local industry and intensified the exploitation of natural resources of the county (Abril 1998), mainly to satisfy the demands of energy and materials of the growing Barcelona city. By the middle of the century, only eight family estates owned

[5] The *rabassa morta* was a particular type of leasing contract specific to vineyard plantation. The tenant was responsible for planting the vines and cultivating them until the death of the stocks (Garrabou et al. 2001), and shared with the landowner about a third of the crop yield.
[6] Tree inventory of Sant Celoni, 27 October 1777, box 8(p), City Archives of Sant Celoni (CASC).

more than 60% of Olzinelles territory.[7] These estates were larger than 100 ha, had a share of forested area higher than 90%, and were the richest of the municipality. The sale of firewood, charcoal, timbers, cork and pastures generated high profits that soon allowed them to rebuild their farmhouses or build new mansions in Sant Celoni village (Abril et al. 1995). In contrast with these wealthy landowners, three quarters of the people registered in the property documents owned less than 3 ha each, and about one third owned plots of less than 1 ha. It was a small wine-producing peasantry made up of small settlers from Olzinelles and humble neighbors of the growing Sant Celoni village that progressively gained access to land through *rabassa morta* contracts with the largest estates. This has been interpreted as a collective solution that allowed the two poles of the rural population to coexist by appeasing the increasing social demand for land while maintaining it productive for the landowners (Garrabou and Tello 2004). The small –or even landless- peasantry of the area provided most of the workforce that the forest exploitation of the large estates required. They worked as day laborers felling trees and shrubs, producing charcoal, debarking cork or in the first phases of in situ timber transformation.[8]

But the wine specialization, spurred on by high wine prices and reduced international competition after the phylloxera plague hit French vineyards in 1867 (Cussó et al. 2006), was coming to an end as the plague approached the vineyards of the area by the last decades of the century. Although Olzinelles had little area occupied by vineyards compared to the more agrarian municipalities of the coast (Nadal and Urteaga 1997) the arrival of the plague must have had a negative impact among many small wine-producing peasants. As in other nearby areas, probably many of them abandoned the vineyards and moved as workforce in Sant Celoni, where a local industry based on textiles, corks, wood and milk was developing since the arrival of the railway (Abril and Portals 2005, see section 5.2 to compare with Matadepera). As Fig. 2 shows, a first drop in the population of Olzinelles took place in 1887.

After 1887 population recovered and maintained around 267 inhabitants between 1897 and 1924 (Fig. 2). But a strong depopulation started as sharecroppers and small estate

[7] These and the following data on landownership and land-uses: *Amillaramiento* of Olzinelles and Vilardell, 1853, TER-963, Archives of the Crown of Aragon.
[8] Book of incomes and expenses of the farm Ca l'Arabia d'Olzinelles, 1880-1887, private archives from the Arabia family. See also Boada (1989: 37) and Piqueras (2009: 108).

owners migrated to coastal towns or industrial villages searching for better paying non-farm jobs and better life conditions, as seen for the Olzinelles valley (Fig. 2 from section 3.6). Most of the peasants and forest day laborers of Montnegre mountains moved to Sant Celoni to find an opportunity in a growing industry that had incorporated electricity in 1909 (Abril and Portals 2005). In 1927 the town council of Olzinelles decided to aggregate its territory to the municipality of Sant Celoni,[9] a symptomatic fact of the already unstoppable demographic loss.

The uneven property structure was going to strengthen with the overturning of the Republican agrarian reform by the Francoist regime after the Civil War (1936-1939) (Tébar 2006). In contrast to the small properties, worked mostly by familiar work, in the largest estates the owner family had sharecroppers, wage-earners and maids living and working in the estate, often managed by an administrator.[10] The aerial photograph of 1956[11] shows a thinned and shrub-free forest that reflects an intensive exploitation. Firewood was obtained from holm oak (*Quercus ilex*), cork oak (*Q. suber*), pine pruning and bushes such as heather (*Erica arborea*). Charcoal was mainly produced with holm oak in the less accessible stands, through controlled combustion of firewood piles covered with earth, so as to reduce firewood weight by 5-6 times and facilitate its transportation while maintaining its calorific content. Wood and timber were supplied by plane tree (*Platanus* sp.), stone pine (*Pinus pinea*), poplar (*Populus* sp.), and alder (*Alnus glutinosa*).[12] Cork debarking was still an important economic activity.[13]

But by the 1960s and as fossil fuels out-competed firewood for cooking, heating and feeding manufacturing processes, profits from forest exploitation started to decrease, and coppicing for firewood and charcoal, as well as shrub clearing, decreased markedly (Otero et al. 2008). Cereal fields and vines were gradually abandoned as people left their farmhouses, making way for oak forests to recover spontaneously and for plane trees and pines to be planted by the landowners (see table 1 from section 3.6). Josep Travesa, small peasant of Olzinelles, remembers that "by that time sharecroppers started

[9] Agreements of the Council plenary of Olzinelles, 1927, box 3(p), CASC.
[10] Demographic census of Olzinelles and Vilardell, 1924, box 121, CASC.
[11] Aerial photographs of Catalonia from the US Army, 1956-57, rectified and provided by the Centre for Ecological Research and Forestry Applications (CREAF) of the Autonomous University of Barcelona.
[12] Permissions for tree felling in the municipality of Sant Celoni, 1956-1987, box 490, CASC. Register of tree felling in the municipality of Sant Celoni, 1968-2002, regional office of the Catalan Ministry of Agriculture (CMA).
[13] Permissions for cork extraction in the municipality of Sant Celoni, 1963-1985, box 490, CASC.

to leave… people got a job in the factories… houses emptied" (Interview #1). From 1853 to 2008 about 300 ha of dry land farming have been abandoned, while forests and tree plantations have increased by ca. 200 ha (Otero et al. in prep).

With the crisis of the forest economy, some landowners of Olzinelles sold their properties to real estate developers (Piqueras 2009: 121), who parceled the estates and sold them for second residencies to rural migrants living in the highly congested peripheries of the Barcelona metropolitan cities (Catalán et al. 2008). The new developments of Olzinelles started in the second half of the 1960s and sprawled into the forests of the north of the municipality with no planning scheme, often with the basic services missing, occupying an area of about 62 ha[14] and generating many negative environmental impacts such as landscape fragmentation and fire hazard (Piqueras 2009). As the new inhabitants of the developments started registering in the censuses (1986) the population rapidly exceeded the demographic maximum reached by the traditional pattern of settlement back in 1860 (Fig. 2). The new developments came together with the construction of the motorway AP-7 connecting the Catalan coastal area with France (1969-1970), which crosses the municipality of Olzinelles, along its north-western limit (Fig. 1C). The urban sprawl in mountainous areas with high ecological value was soon perceived as a threat by the ecologist movement that arose during the last years of the dictatorship and the advent of democracy (Aguilar 2010). After an initial protection in the 1970s, the Montnegre mountains and the adjacent Corredor mountains were declared as a protected park free from urbanization in 1989, covering an area of 14753 ha.[15] A large share of the municipality of Olzinelles (69%) was included in the new Montnegre-Corredor Park, which has the objective of making compatible the conservation of biodiversity with the socioeconomic development of its inhabitants (Otero et al. in press).

[14] Considering only the urban part of the parcels and not the forests within the gardens (Otero et al. in prep; see figure 1C).
[15] The official area of the Park is 15,010 ha (Diputació de Barcelona 1989).

4.4. Management practices and cultural context

4.4.1. General features

As noted in the previous section, the rural economy of Olzinelles has been involved in regional and national markets since at least the 18th century, and especially during the 20th century the socioeconomic evolution has been clearly interlinked to a process of national industrialization and modernization. This makes the case study particularly useful to understand the link between cultural and biological diversity in rural communities that are far from self-subsistence and isolation, in the sense argued by Cocks (2006), and whose natural resources are far from being common-pool. The following analysis of the agrosilvopastoral practices and the cultural features of the local community in the 20th century must be understood as a simplification of a dynamic set of socioecological interactions influenced by a broader process of modernization that has brought many changes. Besides the changes described in the previous section, these also include the mechanization of manual works (farming, harvesting, threshing, tree felling); the substitution of draught animals (mares, horses, bullocks, cows, donkeys, mules) for tractors and trucks; the transformation of wagon tracks in asphalt roads; the employment of the inhabitants in external non-farming jobs (factory laborer, building worker, mechanic, maid, cook); the substitution of old measures for the metric system, the arrival of electricity and telephone in the farmhouses, and the progressive erasure of the cultural beliefs of the peasant community (Otero 2006).

Farmhouses in Olzinelles were usually located near (mostly irregular) streams, which were transformed for dry land farming and orchards around the houses. The richest farmhouses were placed in the valley bottoms of the longest and largest streams flowing from the highest elevations to the river Tordera (Fig. 1B), where the largest and flattest areas were available for cultivation. By contrast, the smallest farmhouses were placed in short and steep streams with less availability of arable land. Depending on the size and the productive activities of the estates, the farmhouses had different buildings and utensils for the transformation of agrarian products (bread oven, wine press, oil mill), conservation of food and drinks (wine-cellar), livestock raising (stable, farmyard),

production of building materials for repairing and reconstructing the farmhouses (lime kiln, brick kiln), and lodging of sharecroppers and farm wage laborers.

4.4.2. Water management

Settlers secured the access to water through different mechanisms. Small accumulation tanks or holes were dug in the streambeds or in places with a subterranean flow of water and conducted through descendant tunnels to ponds, springs and houses. Tunnels had several entries to make possible the maintenance and were signposted with milestones. This water was called "living water" (*aigua viva*), since no energy was needed to make it gush out (Rangil 2009: 64). In places where subterranean water appeared naturally, called "voices of water" (*veus d'aigua*), small accumulation structures and pipes were installed to facilitate the filling of drinking jugs and buckets. Many springs scattered in the forest hills were carefully maintained by forest day laborers to secure water during the working day, especially for cooking soups and for washing. Underground water was extracted by means of wells located near the streams, and rainwater was accumulated in small pools. Water was stored in ponds with a hole in the ground closed by a stick that was removed to water the gardens and irrigated fields. From the source to the ponds and houses and from there to the fields, water was channeled in canals, ditches or small aqueducts to pass over the hollows, often equipped with devices to change the direction of the water and guide it to the desired field. Weirs were constructed in streambeds to increase the water level and divert it for watering. Sinks were constructed near the springs and ponds and where used to wash clothes, for personal hygiene or to water the livestock. In the north-western limit of Olzinelles, water from river Tordera was diverted, conducted to a pond and used to move the millstones of the only documented mill in the municipality (Llovera 2002: 109).

4.4.3. Agrosilvopastoral practices

The local community performed a multiple species management. As shown in tables 1, 2 and 3, a high diversity of species was used for livelihood security and for commercial purposes, keeping options open and minimizing risk (Berkes et al. 2000). The diet was based on bread and vegetables, especially beans, and meat consumption was low (Rangil 2009: 174). Wine was another important food, especially for forest workers and

farmers, who used to drink more than 2 l a day (Boada 1989: 27; Rangil 2009: 166, 191). Nourishment from fields and livestock was completed by gathering mushrooms, asparagus and snails; hunting and fishing a minimum of 16 crustacean, amphibian, fish, bird, and mammal species;[16] and producing honey in cork beehives. Farmhouses weren't self-sufficient in food supply, and as early as in the last decades of the 19th century, some families had to buy cereals and derivatives, vegetables, rice, fruits, wine and oil outside the estate.[17] Cooking, heating and oven feeding relied on fuels obtained from many species: firewood (holm oak, cork oak, strawberry tree), fine firewood from heather, charcoal, vine shoots and old stocks, pine cones, etc. Medicinal plants (Boada 1984), ointments of snake skins (Rangil 2008: 45), pig fat, and lizard or scorpion oils were used as remedies to cure ill people. Diversity within species was also used and promoted, especially in vines and fruit trees (Otero 2006: 180-182). Forest workers and owners used to distinguish up to four varieties of holm oak, each one with specific features of growth, ideal stand density and wood quality.[18]

The multiple-use strategy (MUS) consisted in the management of integrated agrosilvopastoral systems based on local ecological knowledge. Productive activities were strongly integrated by throughputs of matter and energy (Fig. 3). Fertility management through a proper manure allocation was crucial for the feasibility of the system (Cussó et al. 2006). The leasing of pastures by the landowners to foreigner temporal shepherds (Table 3) was partially paid by leaving in the farmyard of the estate the manure produced by the flocks during the night (Rangil 2009: 250). Domestic latrines were periodically emptied and the excrements used to fertilize dry land fields. Manure from cows and pigs was widely used as well (Interview #1). Some of the different types of manure (hen, pigeon, rabbit, sheep, goat, cow, pig, horse, and human) had a specific name and were used for particular purposes according to its properties.

[16] White-clawed crayfish (*Austropotamobius pallipes*), red swamp crayfish (*Procambarus clarkii*), Perez's frog (*Pelophylax perezi*, Rangil 2009: 25), ocellated lizard (*Timon lepidus*), European eel (*Anguilla anguilla*), Chub (*Squalius cephalus*), Mediterranean barbel (*Barbus meridionalis*), common wood-pigeon (*Columba palumbus*), Eurasian blackbird (*Turdus merula*), red-legged partridge (*Alectoris rufa*), European robin (*Erithacus rubecula*, Rangil, 2008: 98), European rabbit (*Oryctolagus cuniculus*), red squirrel (*Sciurus vulgaris*), southern water vole (*Arvicola sapidus*), wild boar (*Sus scrofa*), badger (*Meles meles*, Rangil 2009: 221). Besides feeding, hunting and fishing had an important function as leisure time for men in the peasant community (Boada and Otero 2006).

[17] Book of incomes and expenses of the farm Ca l'Arabia d'Olzinelles, 1880-1887, private archives from the Arabia family.

[18] Memories of Joaquim Draper Méndez, owner of the estate Can Draper, written between 1989 and 1993, private archives from the Draper family.

Integrated agrosilvopastoral systems operated at different spatial scales. The subsistence-oriented fields around the farmhouses fed the people, but also produced fodder, vegetables, stubbles and grain for livestock, which manure was then returned to the fields (Fig. 3). All the organic waste produced in the farmhouse was given to livestock, especially pigs, and converted into animal protein to feed the family. At the large estate and municipality scales, forests played a key role. They provided new arable land to be used after an increase of external demand for cash products, as in the case of vineyard expansion during the wine specialization, which in turn could be later reforested or afforested (see section 4.3). Forest was also a source of key nutrients as potassium through the burning of slashed brushwood and the application of ashes into the fields. The tree layer was used to produce cork, firewood, charcoal and timber. Shrubs were also harvested for firewood and, together with herbs and acorns, grazed by sheep flocks, which while grazing returned to the forest about half of the total manure produced (Tello et al. in press) during the grazing period in Olzinelles.

Holm oak stands, one of the most important in terms of land-cover and economic activity, were coppiced every 7-10 years (Table 1). The trees to be felled were marked with the initials of the landowner using the knob of the axe. Dead, dried up or bent oaks were selected, together with oaks reaching the diameter required by the market. Straight and healthy oaks were favored with an eye on the next harvest, to be done after 7-10 years with the same selection criteria.[19] The third selection was performed 7-10 years after the second one. After additional 7-10 years the cycle restarted, selecting the oaks that were felled 21-30 years ago, which had already recovered by sprouting (Interview #1). The coppice selection system created an uneven-aged stand structure, more resistant to disturbances such as droughts or pests than even-aged ones. Coppicing several stands within the estate allowed the largest landowners to have a yearly yield, while keeping tree-covered land constant and maintaining heterogeneous forests in terms of canopy cover, light availability, and shrub cover. When holm oaks were cut down, the stump was carefully smoothed down with the axe so as to drain water off and avoid the putrefaction of the tree, as in the case of chestnuts (Montserrat 2007: 128). After the felling, dead leaves and twigs were used to protect the soil against runoff

[19] Memories of Joaquim Draper Méndez, owner of the estate Can Draper, written between 1989 and 1993, private archives from the Draper family.

erosion. Land suitability for different tree species was considered according to the aspect of slopes and the fertility of the soil.[20]

Peasants in Olzinelles had a certain capacity to manage environmental surprises, as it has been attributed to many traditional management systems around the world (Berkes et al. 2000). The main uncertain events to deal with were related with the high annual and monthly rainfall variability (see fig. 5 from section 3.6), i.e. crop yields. The storing capacity and the annual consumption of wine and oil were calculated to last for two years to avoid shortages due to hailstorms or droughts, and also because peasants observed that grape and olive crops had biannual maximums (Interviews #1, 15, 17). In the case of olive trees, the pruning and harvesting techniques could be the cause of such particular cycles in yields (Rangil 2009: 198), although there might be specific biological features regulating yields.

4.4.4. Sociocultural mechanisms

All these management practices were embedded in a set of institutions, in the sense of rules-in-use governing the relationship of humans with one another and with their environment. Property rights and rules of access to land were especially important institutions. As explained in section 4.3, private landownership consolidated throughout the transition from feudalism to agrarian capitalism, which in Olzinelles resulted in an uneven access to land from, at least, the mid 19th century. Depending on the access to resources, the distribution of factors of production and yield, and the sort of remuneration, different types of work coexisted (Fig. 3). Forest works were mainly done by male day workers contracted by the forest owner for specific tasks as tree felling, charcoal making, and cork debarking. A fixed day's wage or a yield-depending salary was negotiated before with the leader of the workers group (Boada 1989: 23), made up of 3-11 humble peasants from Olzinelles and other towns of the region. The distance to their farmhouse often required sleeping several nights in wood barracks or out in the open (Interviews #1, 4). Rather than cash, shrub clearing was often paid in-kind with the stumps and firewood of heather and strawberry trees (Boada 1989: 35), tough forest owners could retain between a quarter and a third of the total brushwood yield

[20] Memories of Joaquim Draper Méndez, owner of the estate Can Draper, written between 1989 and 1993, private archives from the Draper family.

(Interview #11). The owner and its male sons could also contribute with several days' work, especially in highly skilled works such as cork debarking.[21] Some of the largest owners used to have 2-3 permanent groups of forest workers given the amount of workforce required by the estate forests. In the last decades the figure of the forest businessmen (*rematants*) became important (Boada 1989: 21). They acted as intermediaries between a landowner and a buyer (i.e. sawmill, although sometimes the businessman could have one sawmill of his own), and distributed with the former the costs of production (workforce, track construction, transport). In general, and in spite of the great social differences, agreements between owners and workers were reached on a trust basis.

Agricultural practices were mostly done with familiar male and female work, though it was crucial whether the family owned the fields or not. In the second case different leasing contracts regulated the distribution of costs and yields between landowners and tenants. Vineyard tenants were obliged to give 20-29% of the grape/wine yield to the owners, and olive growers about 25% of the olives. Besides the fields, leasing contracts sometimes included the farmhouse, where the family lived (Garrabou et al. 2001), and the obligation to assign several days work to the forest within the estate (Interview #4). During the most labor-intensive tasks daily wage-earners could be contracted to hoe and harvest (especially women, interviews #1, 3) or to transport the grape harvest to the farmhouse (Interview #4). Labor could also be exchanged among neighbors, especially in the grape harvests (Interviews #4, 15). Livestock raising within the farmhouses was done mostly by the women of the family. Whereas milk cows were owned by the peasants, some of the calves raised by them and devoted to veal belonged to cattle businessmen that retained between one third and one fourth of the sale price in the slaughterhouse (Interview #7). Cows and sows were brought to neighboring farmhouses to mate with their males, in exchange for some cash or even some baby. Pasture and acorns leasing by landowners to shepherds was paid by cash or in-kind by lambs. Households were almost exclusively managed by women. They were in charge of cooking for all the family and for the workers that came to the estate during the higher labor-intensive tasks of the year (cereal and vine harvests, slaughter of pigs), often forgoing their own feeding in order to secure that of the males, except during pregnancy

[21] Book of incomes and expenses of the farm Ca l'Arabia d'Olzinelles, 1880-1887, private archives from the Arabia family.

and lactation (Rangil 2009: 124). They took care of the conservation of grain and vegetables, which were stored in the loft; the production of pork sausages and cold meats; the preparation of preserves; the drying of vegetables, etc. They also looked after the kids and the elderly of the family and cured the ill people.

To a large extent, social and spiritual life of the local peasant community turned around the two parishes and its cemeteries. Indeed, the Church was one of the most important institutions, and served to achieve social cohesion by legitimizing uneven economic relations driven by the power of landowners. In the churches, rich landowning families of Olzinelles had their own pew with the surname written on it (Otero 2006: 157), and were the ones contributing the most to the parish economy through donations. They had private chapels in their farmhouses. Some of them were good friends with the bishop of Barcelona, who used to spend some days in the estate Draper (Interview #12) or with the Jesuit authorities, who hid in the estate Valls during the Civil War. The ideal of catholic charity with the poor was well rooted: poor families from the neighboring farmhouses and villages were allowed to harvest firewood from the largest estates, spend the night in the hayloft and receive food during some days a year (Interviews #3, 12, 13, 14; Ferrer 2009: 148). Moreover, many paranormal phenomena were attributed to the priest, since he had access to written culture and was able to fight against threatening pests,[22] storms and hailstorms, and to invoke the much desired rain (Rangil 2008).

4.4.5. Transmission and integration of knowledge

Traditional mechanisms of intergenerational transmission of knowledge operated in Olzinelles. Male kids started working with parents and older brothers in the fields and with livestock in the farmhouse (Interview #1). Female kids joined their mother and older sisters in the housework, i.e. taking care of the youngest siblings. Children of the humbler families started working as pig shepherd boys in neighboring farmhouses as early as 6 years old (Interview #11). Young boys were rented out in large farmhouses,

[22] Indicatively, one of the landowners wrote that in May 1887 "a plague of caterpillars was born, leaving us frightened (…) a sort of furry caterpillar which after two months became butterfly, and the butterflies made eggs to breed for the next year, what a plague God sends us, I think this must be a punishment". Book of incomes and expenses of the farm Ca l'Arabia d'Olzinelles, 1880-1887, private archives from the Arabia family.

where they spent several months working as servants in the fields, taking care of the cows or helping forest workers.[23] At 12-15 years old they joined one of the groups of forest workers as apprentices, first with auxiliary tasks (Interview #4) and then with hands-on learning of the most skilled tasks. The group leaders were generally the most skilled workers and taught the younger how to debark cork without harming the bare bark or how to fell trees in the desired direction. The coexistence of 3 generations of the family in the same farmhouse allowed the transmission of a great amount of information. Besides specific hands-on learning of all the tasks, the eldest told stories about the relatives, especially ancestors, going back as far as 200 years (Interview #11).

However, and as Berkes et al. (2000) pointed out, none of the examples of local management is purely traditional and incorporate Western science, and in Olzinelles the integration of knowledge was far from trivial. Practices of forest management were the result of the application of local knowledge, but were regulated by State foresters or land-owners educated in the University. J. Draper, owner of one of the largest estates in Olzinelles, studied agronomy in France, but "who taught me how to know the trees, how to know the weight of standing trees, which trees should be removed to give space to the youngest, and when? Not in France! (…) If I know all this it is thanks to the sharecropper Joan Clapés, who during my childhood and youth taught me, not everything but quite a lot".[24] In the official permissions, government foresters allowed a certain amount of firewood or timber to be harvested, but often forest rangers were convinced to allow a higher amount in exchange for a bribe and with the condition that the felling was not abusive (Interview #2). Similarly, livestock raising was regulated by veterinarians from the state administration, and hunting was also regulated by national rules. Moreover, formal education was progressively implemented in the school of Olzinelles, and the illiteracy of local community gradually decreased (Otero 2006).

[23] Book of incomes and expenses of the farm Ca l'Arabia d'Olzinelles, 1880-1887, private archives from the Arabia family.
[24] Memories of Joaquim Draper Méndez, owner of the estate Can Draper, written between 1989 and 1993, private archives from the Draper family.

4.4.6. Spirituality in nature

Socioecological interactions and practices described above were not the result of a strategy chosen consciously by individuals. Rather, they were codified in a set of traditions and beliefs passed on orally within a particular worldview. In general, tree felling lasted from the end of October until Saint Joseph (19th March), when the trees recovered the sap flow and, according to popular belief, the felling was harmful to the sprouting capacity and the wood yield deteriorated sooner (Interview #1; Gutiérrez 1996: 26). The moon was thought to exert an influence on trees. Evergreen trees (holm oak, cork oak, and pines) were cut down during waxing moon days, while deciduous trees (poplar, plane trees, and deciduous oaks) were cut down on the wane. If this was not observed, wood and timber quality was thought to get damaged soon. Unusually big and long-lived trees were conserved in the edges of forests and fields, along the tracks and near the farmhouses, under which symbolic protection peasants used to meet and make deals on livestock and agrarian products (Broncano et al. 2006: 11, 25). Vines and olive trees (Table 2) were also believed to be under the influence of the moon. The main pruning of vines was done in the waning moon of February or March, while olive trees were pruned with waxing moon (Interviews #1, 11).

Several non-Catholic prayers and simple rituals, especially transmitted by women to daughters and granddaughters, were put in practice to make rain clouds or bad spirits go away and to cure injuries (Rangil 2008: 114, 141). The ladder snake (*Rhinechis scalaris*) was captured alive and its tongue pulled out and hanged inside a small bag on the newborn child's neck to relieve their pain when teeth were coming out. The hedgehog (*Erinaceus europaeus*) was also sacrificed *ad hoc* and its teeth pulled out and used in the same way and for the same purpose. To make fever come down, some people used to catch seven beetles in the dunghill, crush them in a mortar, make an infusion and give it to the sick person without their knowledge (Portals 1998: 111). The wrath of patron Saint Stephen that banished common magpies (*Pica pica*) from Olzinelles after one of them defecated in his bald head during a solemn procession was thought to be the cause of the absence of this species in the area (Interview #3; Otero 2006: 182). Informants from Olzinelles and Montnegre mountains have explained to ethnographer Rangil (2008) many stories about magic creatures that were seen by them or by their relatives. Flying snakes with long hairs in their back and a diamond in their

head (*serpents*) could eat people and kept wonderful treasures (p. 52). Beautiful water women (*dones d'aigua*) lived in hidden underwater palaces and came out from streams with the full moon to do laundry while singing captivating melodies (p. 201). There were also witches able to start storms and kill children (p. 113), and big creatures (*pesantes*) sitting down on sleeping people making it difficult for them to breathe and inducing nightmares (p. 200). People sometimes felt that a fear coming from the dark forests chased them when walking along the paths (p. 143). Anxious lost souls of dead relatives knocked on farmhouse doors, something that was often attributed to the parish priests who justified in this way the need to celebrate additional masses (p. 153).

According to some of our interviewees, local peasants had the capacity to "listen" and "understand" natural elements. As noted above, "voices of water" where places where subterranean water appeared naturally and could be heard. Particularly skilled people in the water issue (*saurins*) could feel the underground water and were contracted to know the exact point where to drill a new well. Even some mushrooms as morels (*Morchella* sp.) were heard crying when they were gathered (Rangil 2009: 213). In the case of cork, Josep Travesa told us that when peelers did not engrave the bare bark with the year (see table 1), in the following peeling it was more difficult to know the age of the cork, and "then you had to look the cork and understand it" so as to know if it was aged enough to be peeled (Interview #1).

Another very important feature of the oral peasant culture, transmitted orally from parent to child, is that by its very nature it resists being fixed. Although folklorists and musicologists have longed for capturing the essence of the vanishing Catalan peasantry since the 19th century (see Amades 1982-83), these works are only academic witnesses of a rich world that once existed. According to the artist Perejaume, although in Olzinelles "there were many human lives (...) many minds working, imagining, inventing" that created a rich culture throughout history, "nothing remains!" The rural world is itself "a great way to disappear and leave no traces". Not only vegetables and cereals were grown, but also space was cultivated. Places grew inside peasants' mind, as they had an extremely detailed knowledge of the nearest fields of the house where they used to spend a great amount of time and effort working the land and thus thinking. Their knowledge of soils, useful plants, paths and place names decreased with increasing distance from the farmhouse, paralleling the distribution pattern of arable

land, to such an extent that even very near woods (5 km far from the farmhouse) were seen as far-off places, wild, foreign, woody and unknown (Otero (dir) 2008). Finally, and as opposed to enlightened academic culture, which "builds great architectural monuments, (...) write and publish books, (...) and is involved in physical works designed to last", the rural world "is used to secrecy and to remaining hidden (...) is an expert on concealing, on discretion"; its culture is "very fragile and has few physical monuments" and consists of "fragile materials, voice modulations, popular forms, festivals, dances…".[25]

4.4.7. Adaptive management

In Olzinelles, the subsistence-oriented activities coexisted with the production of cash products required by the market, as it has been observed in totally different rural communities (Toledo et al. 2003). The institutional and cultural setting described above provided flexibility or ability to reorganize under changing circumstances and to buffer the system from disruption by new economic demands, introduction of new technologies or other changes, and can thus be considered an adaptive system (Berkes et al. 2000). Several examples witness this adaptive capacity. The system was adapted to the peak in wine demand of the last decades of the 19th century by converting forests to vineyards that were later afforested or reforested by the end of the wine fever. In the cork oak stands, the intensity of thinning and the trade-off firewood/cork was flexible to changing prices and to the variable expansion of plagues in cork oak stands. Up to six qualities of cork were carefully separated and sold at different prices according to demand specificities.[26] When scarcity of food and basic items threatened people's livelihoods, as during the rationing of food supplies under Franco's "autarchy" in the post-war period (Aguilar 2010), networks of barters among peasant families were put in place (Interview #5, 12); high productive and less quality varieties of wheat were used (Interview #11), and other products as maize, acorns (Interview #1), or even by-products of wine production as grape seeds (Rangil 2009: 175), were used to increase flour production.

[25] Follow this storyline at the documentary by Otero (dir) (2008).
[26] Memories of Joaquim Draper Méndez, owner of the estate Can Draper, written between 1989 and 1993, private archives from the Draper family.

4.5. Biodiversity loss

Agrosilvopastoral practices almost disappeared with rural exodus (Fig. 2). The socioecological system described in figure 3 has radically changed. Work input from farmhouses to forestry, livestock and farming has almost ceased. Food supply to local population from farming and livestock is not a function of the ecosystem anymore. The capacity of the system to provide cash products to external markets is now lower: wine, milk, calves, pigs and charcoal are neither produced nor traded anymore (except for highly fertile female piglets in just one farmhouse), and the sales of cork, firewood and timber have greatly decreased. No more forest is transformed in arable land, but the opposite trend takes place. About 300 ha of dry land farming have been abandoned, while forests and tree plantations have increased by about 200 ha (Otero et al. in prep). Forests are now denser, have higher fuel load and higher canopy cover compared to the past situation (see chapter 3). As a result, species from fields, meadows and sparse forests have decreased in Olzinelles and, in general, in Montnegre mountains, where similar settlement history, management practices, and land-use changes took place (Piqueras 2009; Guitart et al. 2009; Rangil 2009). Table 4 shows a review of species from different taxonomic groups that seem to be experiencing recessive trends in Olzinelles and Montnegre mountains during the last decades.

Geranium lanuginosum was found in Montnegre mountains in 1946 in clearings where firewood piles were recently burned to make charcoal (Montserrat 1989), and it has never been found again. The disappearance of charcoal making is considered the major threat for this very rare taxon throughout Catalonia, since it appears after carbonizing or burning (Guitérrez 2001). The other plant species (Table 4), with only one or few locations in Montnegre, seem to be threatened by loss of habitat due to decreasing rural activities and consequent afforestation of meadows and open spaces, and forest densification. Moreover, *Isoetes durieui* and *Orobanche artemisiae-campestris picrides* could be already extinct since they have disappeared from the only location known due to afforestation and other changes in habitat (Gutiérrez 2004). The five butterfly species in table 4 showed clear declining trends as maritime pines (*Pinus pinaster*) planted in former grasslands of the farmhouse Can Riera grew and the shadow area increased to 100% (Miralles and Stefanescu 2004). Although in the whole Catalan area these species are not considered grassland specialists but generalist species without clear preferences

(except *Leptotes pirithous*, which has not been evaluated with regard to its preferences, Stefanescu et al. 2007), in Can Riera transect the largest populations of these species were found in grassland sections (C. Stefanescu, personal communication). This means that in a highly forested area such as this one, reforestation of grasslands leads to a rapid decrease in their populations. *Polyommatus icarus* and *Colias crocea* also showed a clear decline after grassland abandonment in less forested areas of Catalonia (Stefanescu et al. 2005).

The five reptile species reported in table 4 are listed in the IUCN Red List of Threatened species. In Olzinelles we have observed a general decreasing trend in their populations related to vineyard abandonment in the last decades. The fact that some of these species as the ocellated lizard (*Timon lepidus*) used to be eaten by local population does not seem to account for such a decrease, since rural population has greatly diminished and new urban settlers (Fig. 2) do not eat lizards. Reduced livestock grazing might also be reducing open areas suitable for this species (Pleguezuelos et al. 2008). *Coronella girondica*, specially related to stone walls in sunny vineyards, has not been observed in the last surveys. Indeed, in Spain it may be locally threatened by a combination of different factors (Sá-Sousa et al. 2008). Bird species listed in table 4 are considered of least concern by the IUCN Red List. All of them highly depend on agrarian fields and the decline experienced in Olzinelles and Montnegre mountains may be attributed to agricultural abandonment and afforestation, perhaps one of the clearest examples being *Galerida cristata.* The decline of partridge (*Alectoris rufa*) is particularly related to vineyard abandonment, as one of the local peasants acknowledges: “there were vineyards and there were lots of partridges, but now partridges are lost” (Interview #3). The negative trend of *Miliaria calandra* seems to be more related to the abandonment of cereal fields. Although *Jynx torquilla* has been always very rare in Olzinelles (Otero 2006: 65) its decline may also be related to agriculture abandonment, since it used to nest in the split trunks of several fruit trees (i.e. fig tree). Abandonment of cultivated land and extensive grazing, shrub encroachment and afforestation, together with agricultural intensification in some cases, are among the major threats for these species at the Catalan level (Estrada et al. 2004). When Catalan populations are evaluated using adapted IUCN criteria, *A. rufa* turned out to be considered as vulnerable, while *J. torquilla*, *L. senator*, and *G. cristata* were classified as near threatened. Among mammals, *Talpa europaea* became rare and *Lepus europaeus* disappeared due to the

loss of agrarian land, tough in the last two years we observed one hare in Olzinelles that was probably coming from a repopulation in the nearby Montseny mountains.

Besides species being affected by afforestation of fields and meadows and by forest densification, rural exodus and decreasing agrosilvopastoral practices may had a negative impact on species that depend on water bodies constructed and maintained by peasants: ponds, springs, pools, ditches, weirs, sinks (see section 4.4.2). Only in Olzinelles valley, which accounts for one third of the study area, 5 springs, 5 ponds and several ditches and sinks were found abandoned and dry. Some amphibians as *Pelodytes punctatus* and *Pelobates cultripes* suffered a strong decline, while others as *Pelophylax perezi*, *Hyla meridionalis* and *Triturus marmoratus* experienced a moderate decrease. All of them are included in the IUCN Red List, being the loss of natural and human-made breeding sites one of the major threats (Denoël et al. 2008; Beja et al. 2008; Donaire-Barroso et al. 2008; Willem Arntzen et al. 2008). However, the introduction of predatory exotic crayfish *Procambarus clarkii* and the loss of water stream flow (see chapter 3) in the last decades may also account for the decrease in amphibian populations. The decline of some reptiles as *Anguis fragilis* seems also related to the disappearance of irrigated fields and meadows. Finally, the diversity within cultivated species, especially fruit trees and vegetables, has surely decreased since it was enhanced by long-term human selection of the preferred genotypes in terms of adaptation to local climate, taste, productivity, etc. (Otero 2006: 180).

4.6. Socioecological heritage. Linking diversity with sustainability

We have shown that the abandonment of a diverse set of agrosilvopastoral practices placed in a specific cultural context, a particular geographical setting and a defined temporal scale, is related to a decline of several species from different taxonomic groups. In Olzinelles, the distinctive set of accumulative patterns of socioecological interactions and practices yielded a particular configuration in both cultural and biological diversity. This "selection" of human-nature interactions that enhances both biological and cultural settings may be named as *socioecological heritage*, which is as much an outcome as a process, given that the actual permanence of such heritage depends upon the possibilities to implement the knowledge gained and which is being gained by the practice of it. This concept has many things in common with previous

definitions of heritage, which in general terms is considered a set of things that people wish to save from oblivion (Howard and Pinder 2003) or a selection of the past for contemporary uses and future strategies (Van Gorp and Renes 2007). It also offers the possibility to overcome the existing division between natural and cultural heritage, as well as between tangible and intangible heritage, by acknowledging the arbitrariness of these categories and their interrelatedness (Kirshenblatt-Gimblett 2004; Kurin 2004). Socioecological heritage is thus in agreement with, and may contribute to, some holistic considerations of heritage as "relations" more than as "separate objects", such as the notion of cultural landscapes (Rössler 2006; Farina 2000), the UNESCO's Man and the Biosphere Programme, or the culture-nature hybrids (sensu Latour 1993) such as wild birds (Tàbara 2006) or mountains (Darier and Tàbara 2006).

It could be argued that considering as socioecological heritage something that appears to be the outcome of the reproduction of high social inequalities may be not only naïve, but also lead to reactionary politics of biodiversity conservation. We do not want to offer a romantic view of the past since large injustices were committed and poverty and miseries were suffered by most of the population. Angelina Pujol, housewife of a sharecropper family, told us that life in her farmhouse "was very hard, very bad, for me, because I was always alone, night and day" and she "never opened the door to anyone, because I was so frightened" (Interview #8). She took care of three children, washed clothes, cooked and managed the cattle and the garden in a farmhouse without electricity, running water and telephone. This was not one century ago but happened in the 1970s. On the contrary, the notion of socioecological heritage acknowledges the ability of peasant communities to use local resources for self-subsistence and for trading purposes in a conservative manner. Most of the community was made up of humble peasants that were obliged to manage properly their own resources to survive. The "environmentalism of the poor" described by Martinez-Alier (2002) seems to be highly relevant for Mediterranean developed countries too, where the notion of "indigenous" or "local" communities is challenged (Cocks 2006). Nevertheless, it must be also acknowledged that the decrease in the historical intensity of land-use may lead to the recovery of some ecosystem services such as carbon sequestration and soil conservation (Rudel et al. 2005) and also to the increase in the populations of several species, i.e. wild boar (*Sus scrofa*).

The analysis of Olzinelles offers material for a rebuttal of the argument that out-migration of poor peasants to cities enhances the recovery of the natural ecosystems (Aide and Grau 2004, see section 2.1), which can lead to extremely asocial conservationist policies. It also suggests investigating further the relationship between human appropriation of ecological production and species diversity, and specially testing whether the hypothesis that an increase in the former is related to a decrease in the latter as shown by HANPP studies (Haberl et al. 2004, 2005) is valid in Mediterranean cultural landscapes where landscape heterogeneity plays a key role in maintaining species diversity (Benton et al. 2003). As Berkes et al. (2000) state, many traditional management systems contribute to the conservation of biodiversity through a number of practices, including the use of more varieties, species, and landscape patches than do modern agricultural and food production systems. Drawing on such practices (what has been called here socioecological heritage) and understanding the social mechanisms behind them may speed up the process of designing alternative resource management systems. Cultural and natural diversities are not to be considered an annoyance or a threat to progress, but a global common heritage which needs to be preserved for the generations to come (Tàbara and Giner 2004). In spite of being highly intangible, the memory of the peasant universe is enough for us to glimpse other possible realities. As stated by Perejaume, who professed a high respect for Pepitu,

> [when he was alive and] "you were in Can Pau Foguera, that reality was not at all nostalgic, it was rather the other way around; there was the possibility of perceiving that another concept of reality was possible (…) It was more like a revolutionary vision, as far as you could realize that there was another possibility in the world: a parallel world".

4.7. Figures and tables

Figure 1A: Location of Olzinelles. Source: own elaboration.

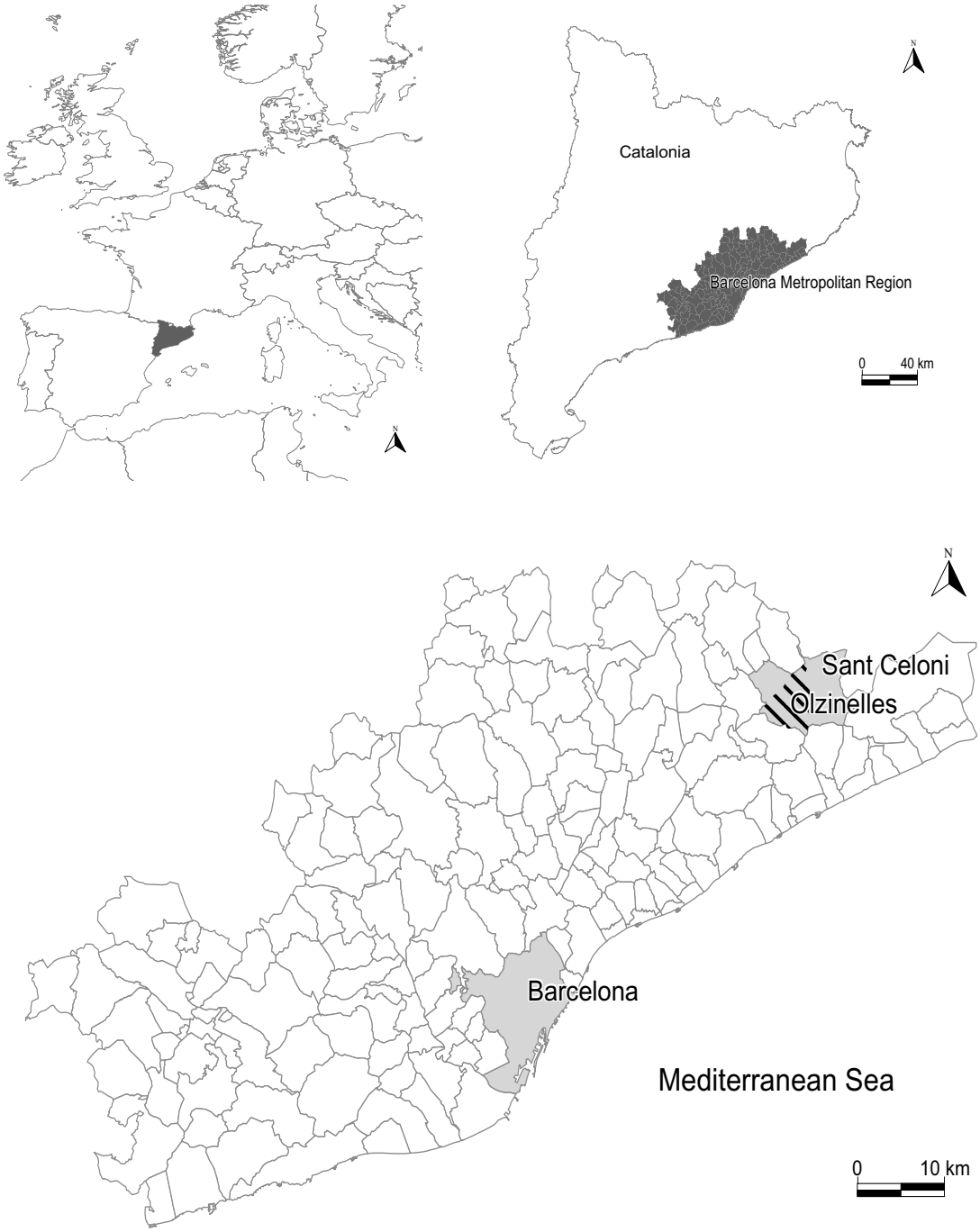


Figure 1B: The old municipality of Olzinelles is located in the north-western side of Montnegre mountains. Small streams such as Olzinelles stream flow from the highest elevations to the Tordera River (see figure 1 from section 3.6). Settlement has traditionally been structured in dispersed farmhouses (Can Valls, Can Riera de Vilardell…) and organized around two parishes. Source: Prepared by D. Varga.

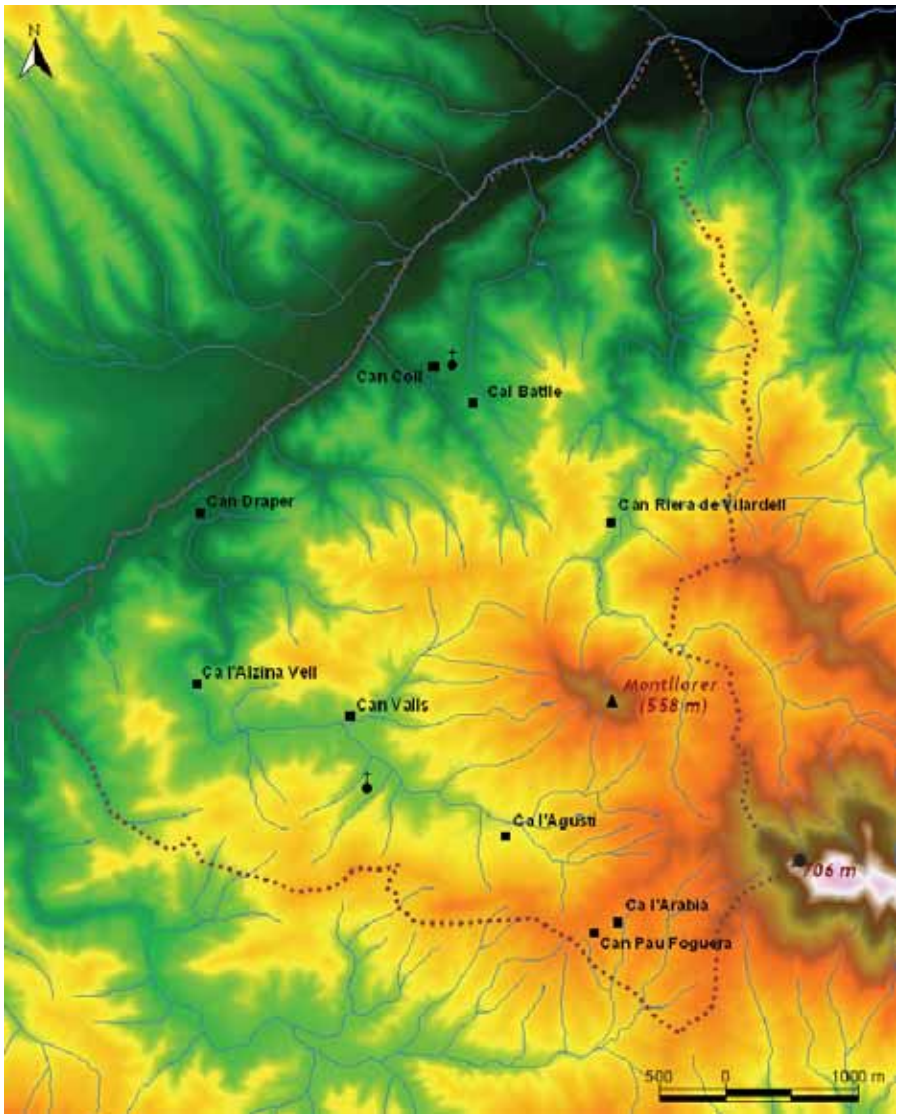


Figure 1C: Land-cover map of the old municipality of Olzinelles. In the last decades, urban developments have sprawled in the estates Can Coll and Cal Batlle (see figure 2). The motorway AP-7 crosses the old municipality of Olzinelles along its north-western limit. Source: Otero et al. (in prep).

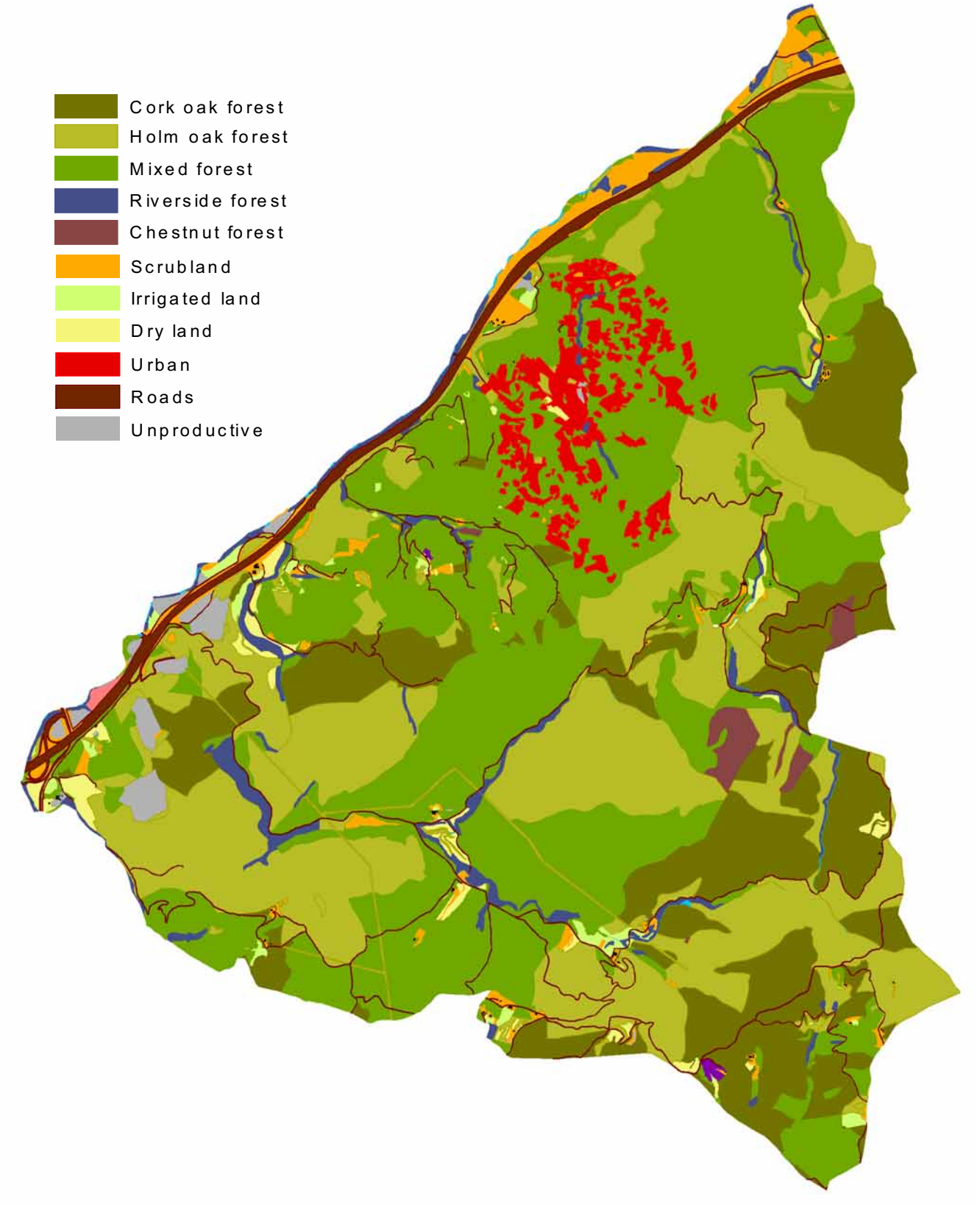


Figure 2: Demographic evolution of Olzinelles, 1842-2007. Source: censuses from City Archives of Sant Celoni and Parish Archives of Olzinelles, Abril et al. (1995) and Piqueras (2009).

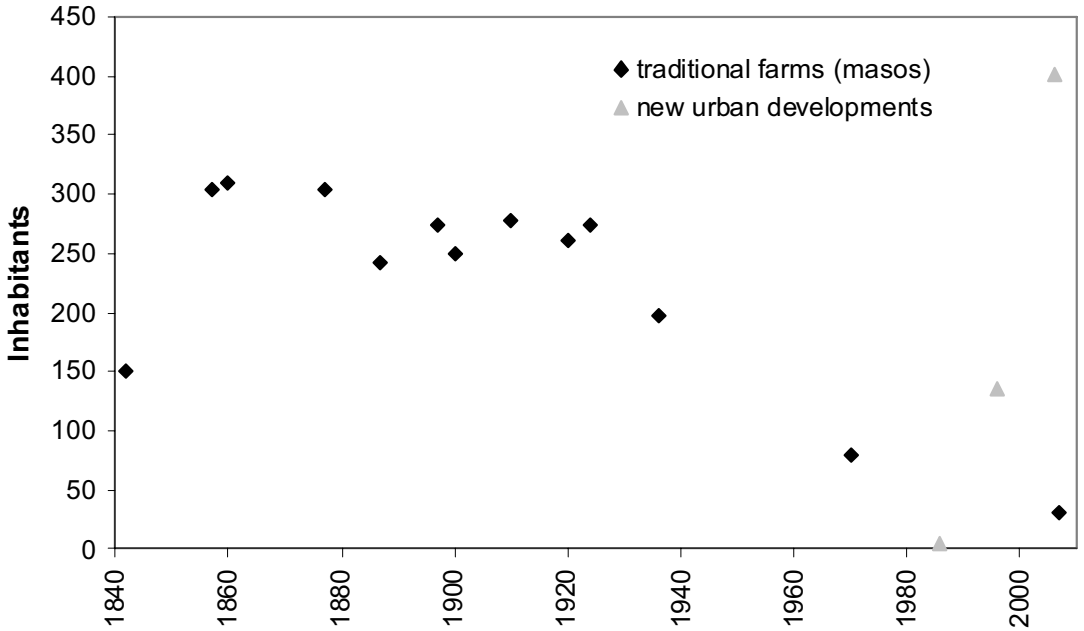


Figure 3: The open socioecological system of Olzinelles: integration of productive activities and adaptation to external demands. Source: Oral sources, archival data, field work and GIS (see methodological approach in section 4.2).

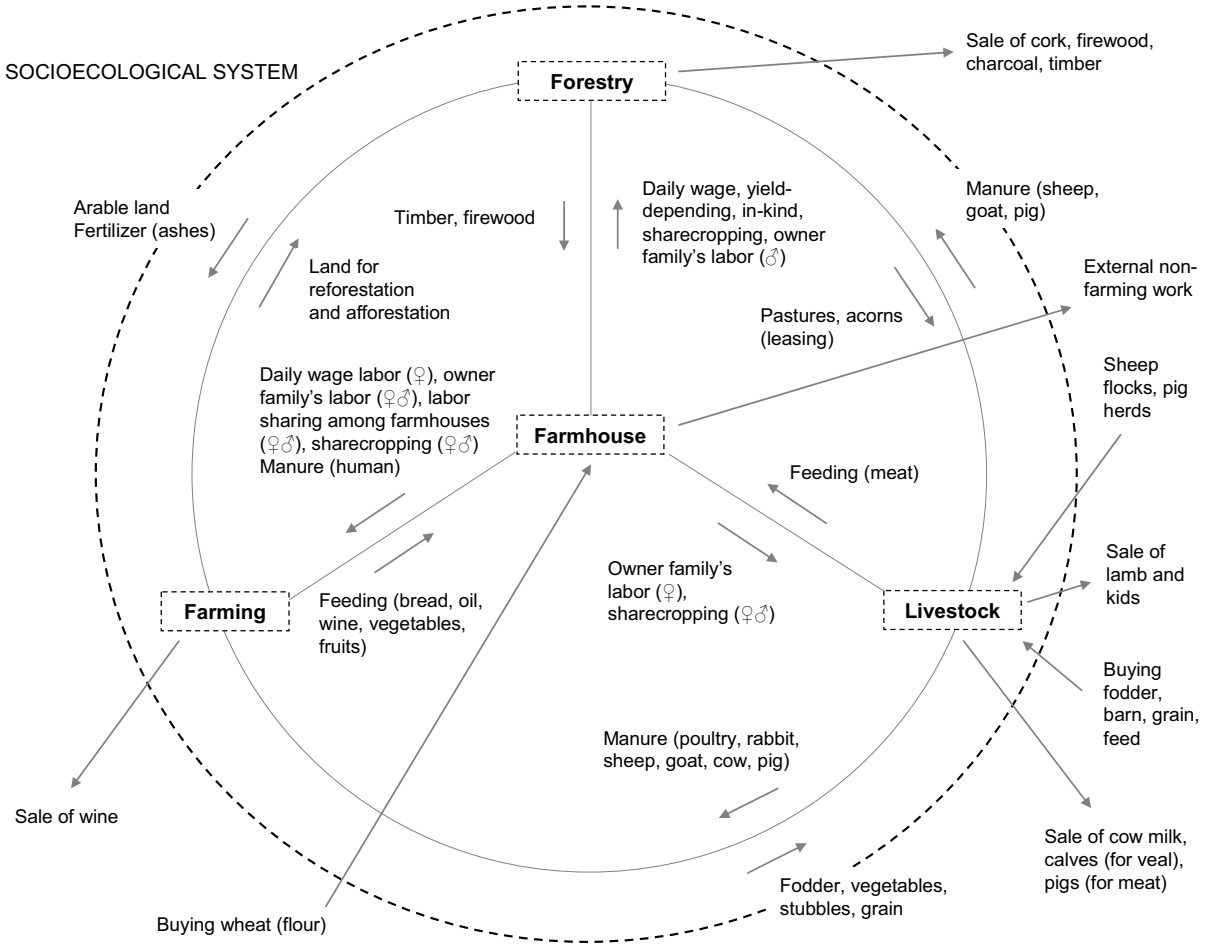


Table 1: Forest management in Olzinelles in the 20th century. Source: Oral sources, archival data, field work and GIS (see methodological approach in section 4.2). Additional information from Boada (1989), Pagès et al. (2005) and Piqueras (2009).

Cork oak stands (*Quercus suber*)	Debarking virgin cork from trees of < 20 cm Ø (June-July). Debarking secondary cork 9-10 y after virgin cork (June-July). Debarking 12 y after secondary cork (June-July). Debarking every 14-17 y up to five times (June-July). Tree divided vertically in 2-3 stretches, one to be debarked 4 y after the former. After the peeling, bare bark engraved with the year so as to know the age of the next cork.
	Coppice selection. Felling competitor species (*Pinus pinea*, *Quercus humilis*). Selective slashing of ground vegetation every 20 y (*Erica arborea*, *Rubus ulmifolius*), conserving soil-improving leguminosae species (*Ulex parviflorus*, *Sarothamnus scoparius*) and other useful species (*Arbutus unedo*).
	Charcoal making in the less accessible stands (in piles).
	(Acorn) grazing by pig herds and sheep flocks.
	Cultivating fodders (*Lathyrus* sp.), cereals (*Sorghum vulgare*) and vegetables in low density woodlands.
Holm oak stands (*Quercus ilex*)	Coppice selection every 7-10 y with complete cycles of 21-30 y. Selection of 4 sprouts per stump after 5-6 y and later selection of 2 sprouts per stump. Felling competitor species (*Pinus pinea*, *Quercus humilis*, *Rubus ulmifolius*).
	Charcoal making in the less accessible stands (in piles).
	Grazing by pig herds and sheep flocks.
Understorey	Slashing before tree felling. Felling and uprooting stumps from *Erica arborea* and *Arbutus unedo*.
	Fine charcoal (*carbonet*, *carbó de branca i rabassa*) making in kilns, pits or piles.
Riverside	Almost parallel layout of species according to their need of water, from the river to the outside: *Alnus glutinosa*, *Populus* sp., *Platanus* sp., *Pinus pinaster*, *Pinus radiata*. Felling with different rotations.
Pine plantations (*Pinus* sp.)	Pruning of lower branches to stimulate growth (*Pinus pinea*). Felling with different rotations (*Pinus pinea*, *P. pinaster, P. insignis, P. halepensis*).
	Gathering of pine cones (*Pinus pinea*).
Chestnuts groves (*Castanea sativa*)	Deforesting. Sowing chestnuts or planting striplings. Felling after 14-15 y to stimulate sprouting. Selection of 2-4 sprouts per stump after 4-5 y. 1-2 additional sprout selection. Felling 10-20 y after the first felling.
Plantations of plane trees (*Platanus* sp.)	Planting saplings. Felling after 2 y to stimulate sprouting and growth. Selection of 5-12 sprouts per stump (1^{st} y) and 4-5 sprouts per stump (2^{nd} y). Selection of 2-3 sprouts per stump and pruning (4^{th} y). Felling bent trees (6^{th} y). Selection of 1-2 sprouts per stump (12^{th} y). Felling (20^{th} y).
	Cultivating vegetables for self-consumption and livestock feeding.

Table 2: Farming practices in Olzinelles in the 20th century. Source: Oral sources, archival data, field work and GIS (see methodological approach in section 4.2). Additional information from Baylina et al. (2006).

Gardens	Terracing and maintaining edges with stones, trees, shrubs, fruit trees or vines.	
	Constructing and maintaining ponds and ditches to irrigate with stream and underground water.	
	Conserving soil fertility: animal manure, crop rotation, green manure.	
	Growing vegetables for self-supply: fruits (tomato, pumpkin, aubergine); bulbs (onion, leek); leafs and stems (lettuce, endive, chard); flowers (artichoke); legumes (bean, pea); roots (turnip, carrot, beetroot) and tubers (potato). Growing vegetables for livestock: beetroot, turnip.	
Dry land fields	Terracing and maintaining edges with stones, trees, shrubs, fruit trees or vines.	
	Conserving soil fertility: animal manure, crop rotation, green manure.	
	Cultivating cereals and leguminosae for fodder, hay and grain for livestock: oats (*Avena sativa*), barley (*Hordeum vulgare*), lucerne (*Medicago sativa*), maize (*Zea mays*), sorghum (*Sorghum vulgare*).	
	Cultivating wheat (*Triticum* sp.) for self-supply.	Ploughing, fertilizing and sowing (before Christmas). Hoeing. Harvesting and piling up wheat in sheaves (late June and July).
		Transportation of dry sheaves from the fields to the threshing floor. Threshing (late July). Separation of grain and straw, grain collecting and haystack formation.
		Grinding and producing flour and bran. Bread kneading and baking.
		Shifting wheat varieties (productivity vs. quality) according to demand.
Vineyards	Cultivation in steep slopes without terracing, vines laid out following zigzag ditches. Controlling soil erosion and collecting water by zigzag draining ditches and pools.	
	Cultivation in flat fields, vines laid out in lineal furrows.	
	Conserving soil fertility: animal manure, green manure (*Lathyrus* sp.).	
	Cultivating vine (*Vitis vinifera*) and producing wine for self-supply and trading.	Planting new vines to substitute old ones, hoeing, fertilizing and pruning (January-February). Ploughing and grafting vines older than 3 y (March-April). Hoeing, pruning (buds and leafs) and fumigating with sulphur (May). Hoeing, pruning (shoots) and fumigating with copper sulphate (June-July). Hoeing, harvesting and transportation of grapes to the farmhouse (Sept.-Oct.).
		Treading and pressing the grapes, (boiling and) fermenting the juice to produce different kinds of wine (red, white, sweet, dry). Conservation of wine in barrels.
		Use of several vine varieties with different ripening times, tastes, etc.
	Secondary crops.	Medicinal and aromatic plants (rosemary, oregano, sage, thyme); fruit trees (olive trees, fig trees, cherry trees); fodders (lentils, vetches).
Fruit trees	Cultivating olive tree (*Olea europaea*) and producing oil for self-supply (and trading).	Planting in olive groves or as secondary crops in vineyards. Pruning. Harvesting and transport of olives to the farmhouse (November-December).
		Crushing the olives in the oil mill, pressing the paste in the press with boiling water and collecting the oil.
	Cultivating fruit trees for self-supply (and trading).	Planting as secondary crops in vineyards and edges.
		Maximizing species diversity: cherry tree (*Prunus avium*), fig tree (*Ficus carica*), peach tree (*Prunus persica*), pear tree (*Pyrus communis*), almond tree (*Prunus amygdalus* var. *dulcis*), plum tree (*Prunus domestica*), walnut tree (*Juglans regia*), loquat (*Eriobotrya japonica*), quince tree (*Cydonia oblonga*), apple tree (*Malus domestica*), jujube (*Ziziphus jujuba*), persimmon (*Diospyros kaki*), and hazel tree (*Corylus avellana*).
		Use of several varieties within the same species.
Other crops	Crack willow (*Salix* sp.) used to manufacture wicker baskets; reed (*Arundo donax*) used in the orchards; hackberry (*Celtis australis*) to make hayforks and other tools.	

Table 3: Livestock management in Olzinelles in the 20th century. Source: Oral sources, archival data, field work and GIS (see methodological approach in section 4.2).

Bovine	Producing cow milk for trading (and self-supply).	Mating in farmhouses with bulls or artificial insemination by a veterinarian. Alternating gestations to secure milk production. Renewing straw beds and taking manure out the shed every day. Milking and watering twice a day. Feeding: fodder and hay (lucerne, vetches, *Lathyrus* sp., herbs from field edges), bran mixed with beetroots, feed. 1-6 cows and 30-120 daily l yield per farmhouse.
	Raising calves for trading.	Mating in farmhouses with bulls or artificial insemination by a veterinarian. Renewing straw beds and taking manure out the shed every day. Start raising new baby calves before the slaughter of the oldest. Feeding: cow milk, fodder (*Lathyrus* sp.), feed. 3-4 calves per farmhouse, slaughter at 1.5-2 y around 300 kg each.
Pigs	Fattening for self-supply.	Mating in farmhouses with boars. Feeding: mix of bran and boiled vegetables (beetroots, turnips, potatoes), acorns. 1-2 pigs per farmhouse slaughtered yearly to produce cold meats and sausages.
	Fattening for trading.	Stabling the herds in the farmhouse. Feeding: mix of bran and boiled vegetables (beetroots, turnips, potatoes), feed. Grazing acorns (winter) and roots in the oak woodland (also after sheep grazing). Herds of 100-200 pigs.
Poultry and rabbits	Breeding for self-supply (and trading).	Feeding: *Lathyrus* sp., by-products of grape pressing, herbs from field edges, lucerne, bran. Animals kept alive until the day they were cooked and eaten as a way of food conservation.
Ovine and goats	Raising for self-supply.	Feeding 1-2 animals per farmhouse: lamb, ram (castrated), ewe, goat or kid.
	Raising for trading.	Flocks from the region grazing in Olzinelles for some months and alternating pastures with nearby mountains (Montnegre, Corredor, Montseny). Transhumant flocks coming from eastern Pyrenees grazing in Olzinelles from November until springtime.
		Continuous mating. Periodical withdrawal of old ewes. Setting aside from slaughter baby females to substitute old breeding females. Setting aside from slaughter several baby males to substitute old males. Exchanging males with other flocks so as to “change the blood” of the flock.
		Grazing herbs, stems, shrubs, shoots, lower branches of trees and acorns in the oak woodland (not after pig grazing). Grazing cereal fields (oats) and stubble fields after harvest. Use of goats to suckle lambs (occasional). Salt supply by the shepherd every 1-2 weeks in special stones placed in shady woods where the flock sleeps during the hottest hours of the day (*amorriadors*).
		Putting the flocks out to pasture by sheepdogs or children. Flocks in farmyards during the night. Unweaned babies kept with mothers in the farmyard all the day. Wool shearing (May).
		200-400 heads, mostly ewes and lambs, with several goats, kids, rams (castrated and not) and billy goats.

Table 4: Species experiencing recessive trends in Olzinelles and Montnegre mountains as a consequence of ceasing agrosilvopastoral activities.

Group	**Source**	**Area**[g]	**Species**	**Conservation status/interest**	
				UICN[h]	**Catalonia**[i]
Plants	Gutiérrez (2001)[a]	Adapted to Montnegre mountains	*Geranium lanuginosum*	n.p.	CR*
			Orobanche artemisiae-campestris picrides	n.p.	VU
			Spergularia purpurea	n.p.	VU
			Erica cinerea	n.p.	LC
			Helianthemum tuberaria	n.p.	LC
			Isoetes durieui	n.p.	LC*
			Orobanche teucrii	n.p.	LC
			Stachys alpina	n.p.	LC
Butterflies	Miralles and Stefanescu (2004)[b]	Can Riera de Vilardell (Olzinelles)	*Maniola jurtina*	n.p.	n.e.
			Polyommatus icarus	n.p.	n.e.
			Lycaena phlaeas	n.p.	n.e.
			Leptotes pirithous	n.p.	n.e.
			Colias crocea	n.p.	n.e.
Reptiles	Own data[c]	Olzinelles	*Timon lepidus (=Lacerta lepida)*	NT	n.e.
			Psammodromus jeanneae	LC	n.e.
			Rhinechis scalaris (=Elaphe scalaris)	LC	n.e.
			Malpolon monspessulanus	LC	n.e.
			Coronella girondica	LC	n.e.
			Anguis fragilis	n.p.	n.e.
Birds	Ribas (1996, 1997a, 1997b)[d] and own data[e]	Adapted to Olzinelles	*Alectoris rufa*	LC	VU
			Coturnix coturnix	LC	DD
			Jynx torquilla	LC	NT
			Lanius senator	LC	NT
			Miliaria calandra	LC	LC
			Galerida cristata	LC	NT
			Alauda arvensis	LC	LC
			Upupa epops	LC	LC
			Emberiza cirlus	LC	LC
Mammals	Own data[f]	Olzinelles	*Talpa europaea*	LC	n.e.
			Lepus europaeus	LC	n.e.

[a] Review of studies on the flora of Montnegre-Corredor area done by several botanists over the last 60 years (i.e. Montserrat 1989) and selection of taxa according to different conservation criteria (Gutiérrez 2004); in situ verification of the reported locations and analysis of major threats for each taxon.

[b] Transect walked in Can Riera de Vilardell (see fig. 1B for its exact location) as part of the Catalan Butterfly Monitoring Scheme, which uses a standardized methodology for monitoring butterflies (Stefanescu 2000). Between March and September weekly butterfly counts were made along a fixed route within 2.5 m on each side and 5 m in front of the recorder (see Pollard and Yates (1993) for details on the methodology). The transect was 2298 m long, had a mean altitude of 260 m a.s.l. and went through different habitats as holm oak forest, cork oak forest, and former meadows transformed to pine plantations. Data was available for the period 1994-2003.

[c] Based on continuous and long-term biodiversity monitoring of the study area by one of us (M.B.) during the last thirty years, gathered in several books and academic works (Boada 1984; Boada 1990; Otero 2006).

[d] Bird species distribution was studied by field sampling, the study area being divided following the UTM 1 km x 1 km squares. Each of these UTM squares were sampled once or twice a year during several years for both breeding (from March to July) and wintering (from November to February) species. In each sampling, a transect of about 1-1.5 h of duration was made each year by walking within each UTM square. Along these transects, bird species were recorded by both visual and hearing contacts, and main habitat preferences were assigned to each of them (Pino et al. 2000). Different standard methods were used to quantitatively assess bird populations, namely total censuses, parcel censuses and punctual indexes of abundance (Ribas and Pons 2001).

[e] See note c.

[f] See note c.

[g] When indicated, we have adapted the original results by including only those species reported for Olzinelles or, if not possible, for Montnegre mountains.

[h] IUCN Red List of Threatened Species (IUCN 2009); n.p.: species not present in the Red List.

[i] Plants: IUCN criteria (1994 version) adapted to Catalonia by Gutiérrez (2004), * considered VU by Sáez and Soriano (2000) according to the same criteria and geographic scale; Birds: IUCN criteria adapted to Catalonia by Estrada et al. (2004); n.e.: no published evaluation is available according to our knowledge.

5. WATER SCARCITY, SOCIAL POWER AND THE PRODUCTION OF AN ELITE SUBURB. THE POLITICAL ECOLOGY OF WATER IN MATADEPERA[1]

Abstract

This article investigates the history of land and water transformations in Matadepera, a wealthy suburb of metropolitan Barcelona. Analysis is informed by theories of political ecology and methods of environmental history; although very relevant, these have received relatively little attention within ecological economics. Empirical material includes communications from the City Archives of Matadepera (1919–1979), 17 interviews with locals born between 1913 and 1958, and an exhaustive review of grey historical literature. Existing water histories of Barcelona and its outskirts portray a battle against natural water scarcity, hard won by heroic engineers and politicians acting for the good of the community. Our research in Matadepera tells a very different story. We reveal the production of a highly uneven landscape and waterscape through fierce political and power struggles. The evolution of Matadepera from a small rural village to an elite suburb was anything but spontaneous or peaceful. It was a socio-environmental project well intended by landowning elites and heavily fought by others. The struggle for the control of water went hand in hand with the land and political struggles that culminated – and were violently resolved – in the Spanish Civil War. The displacement of the economic and environmental costs of water use from few to many continues to this day and is constitutive of Matadepera's uneven and unsustainable landscape. By unravelling the relations of power that are inscribed in the urbanization of nature (Swyngedouw 2004), we question the perceived wisdoms of contemporary water policy debates, particularly the notion of a natural scarcity that merits a technical or economic response. We argue that the water question is fundamentally a political question of environmental justice; it is about negotiating alternative visions of the future and deciding whose visions will be produced.

[1] This chapter is in press in *Ecological Economics*, being the authors Iago Otero, Giorgos Kallis, Raül Aguilar, and Vicenç Ruiz. The authors would like to thank the oral sources of the study, and G. Estany, À. Carles, E. Dot, H. Gonzàlez and E. de Rueda for the transcriptions of the interviews. An earlier draft of the paper was reviewed by R. Garrabou, D. Saurí, S. Barca and H. March. N. Kosoy, P. Roca, F. Font, M. Borrós, C. Morral and M.A. Vila provided comments and technical help. Part of the research has been funded by the Town Council of Matadepera and by the Diputació de Barcelona.

5.1. Introduction

Climate change and regional water crises have fuelled interest on the growth of water consumption in urban and peri-urban areas. In Spring 2008 the Barcelona Metropolitan Region experienced one of the worst water shortages of its recent history. Reservoirs at the Ter–Llobregat river system, which supplies Barcelona and suburbs, fell to 20% of their capacity (La Vanguardia, 2 April 2008). Growing water demand from low-density suburbanization is at the heart of Barcelona's problems, as consumption in the city centre declines (March and Saurí 2010; Saurí 2003). Despite vocal opposition from environmental and rural interests, proposals to desalinate or transfer water from distant rivers such as Ebre and Rhone dominate media and public discourse (El País, 31 March 2008). In the dominant discourse, the process of suburbanization is seen as spontaneous, inevitable and overall a social progress, albeit with corrigible problems. Water scarcity is seen as a natural condition that Barcelona and its communities have continuously to battle against.

This article advances three counterarguments based on a political ecological perspective of water and urbanization (Swyngedouw 2004) and contributing to the theoretical development of the case against the expansionist water paradigm and in favor of a "new water culture" (Estevan and Naredo 2004). First, (sub)urbanization is anything but spontaneous, in the sense of being outside deliberate political choice. A detailed study of Matadepera, an affluent suburb in the outskirts of Barcelona, shows that its historical evolution from a small rural village to an elite suburb was a socio-environmental project deliberately promoted by ruling elites and opposed fiercely by others. The second argument is that water scarcity is not a universal, physical condition. Scarcity is a function of water demands and hence partly socially produced (Naredo 1997). Matadepera had enough water to satisfy local needs. Water was scarce only in the context of the water demands for the gentrified urbanization of the town. Yet scarcity was discursively mobilized to garner public consent for controversial aspects of this urbanization process. Finally, against prevalent assumptions, this article questions whether the transformations experienced in places like Matadepera can be characterized as progress. Gross injustices were – and are – committed and justified in the name of progress. The actual historical trajectory of Matadepera was not necessarily the best possible. Left-wing Republicans in the 1930s envisaged a balanced territorial

development based on autonomous small farmers. This vision was crushed violently by Franco's dictatorship, protecting the vested interests of landlords. Discourses about the inevitability of progress disguise that there were alternatives in the past, and so foreclose the options for the future.

Matadepera is a small suburban township in the outskirts of Barcelona (Fig. 1). Its landscape holds surprises for first time visitors. Arriving on a spring day at the town's centre, you would think you were in any Mediterranean village: cobbled streets and a plaza, elders sitting in the benches, kids playing football and construction workers having their lunch-break beer. Drive a few minutes out of the centre towards the surrounding forest hills and you find yourself in a replica of California's Beverly Hills: walled mansions with guards, towers, angry dogs, lawns watered by immigrant gardeners, swimming pools and expensive cars with posh drivers. Matadepera is one of the municipalities with the highest per capita income in Catalonia. Although surrounded by forests, Matadepera has some 37 ha of lawn, covering 10% of its urbanized area. There are some 1000 pools in a town of about 9000 people (Estany et al. 2008b). The average personal water consumption, about 400 lt per capita per day (lpcd), is very high by Spanish or European standards, three times higher than the average in central Barcelona.

This article tells the story of the ecological–economic evolution of this peculiar land and waterscape. Although urbanization in Matadepera took off after the 1970s, we focus on the historical period before and after the Spanish Civil War (1936–1939). We argue that the origins of Matadepera's urbanization have to be traced in this particular period when alternative visions about the future of the territory clashed and the broad contours of what was to follow were laid out irreversibly. Our historical study relies on two primary data sources. First: an exhaustive review of the City Archives of Matadepera. All formal communication between Matadepera's municipal authorities and external individuals or agencies, was collected for the period 1919–1979. Key documents about water, land and political conflicts were identified, photocopied and text coded.[2] Second, interviews were held with 17 individuals born between 1913 and 1958 who experienced specific events related to the pre, Civil War and Francoist periods. The sample of interviewees was

[2] For detailed references on archival sources, see Ruiz et al. (2008). Available at: http://www.raco.cat/index.php/Terme/.

balanced in terms of right and left-wing political sympathies, occupation and socio-economic profile. Interviews lasted between one and two hours. They were recorded with a video camera and/or a digital recorder and transcribed. Additional policy documents were collected, including territorial planning reports, water company publications and plans and related laws, as well as secondary literature including a history of Matadepera's hydraulic works, written by the priest of the village (Ametller 2002), who was also interviewed. A content analysis was performed for all interviews and selected municipal documents, codifying key terms, and identifying cross-cutting themes.

The results are presented in the form of narrative (Cronon 1992) written from the vantage point of political ecology. Whereas ecological economics maintain a binary distinction between society and nature, the former enclosed within the boundaries of the latter, political ecology advances an intertwined perspective, where the process of metabolic "production" fuses society and nature. From a political ecology perspective city and nature are not disjointed, antithetical entities; cities metabolize nature, producing new, urbanized natures (Swyngedouw 2004). This does not deny degradation; produced natures may be seen as better or worse according to different valuation criteria. Uneven power relationships produce uneven control of water and other resources, and socially uneven (urban) landscapes with unequal distribution of the costs and benefits of ecological–economic change among social groups (Martinez-Alier 2002; Naredo 1997; Swyngedouw 2004). Water resource development is part and parcel of urbanization (Kallis 2010; Swyngedouw 2004). The question is not whether water causes urban growth or not (obviously water is a necessary but not sufficient factor for growth), but how, by whom and for what purpose water is mobilized in the process of urbanization. Scarcity from a political ecology perspective is not absolute and nature-given, but socially produced (Bakker 2000). This does not deny that scarcity is a function of physical conditions, but it emphasizes that it is also a function of population and consumption levels within artificially-defined territorial limits, as well as technological and institutional capabilities that change over time (Meerganz von Medeazza 2004). A major insight of political ecology concerns the ways in which the specter of scarcity and its framing as a natural phenomenon are discursively employed to serve the interests of the elites who profit from the social processes that produce this scarcity, often in the name of solving it (Kaika 2005). Framed as a collective, natural

problem, scarcity galvanizes support for those in power and depoliticizes choice (Nevarez 1996; Swyngedouw 2004). All this might seem too abstract, but the story of Matadepera will demonstrate its empirical relevance. This article brings together political ecology with its focus on power and justice, and environmental history, the study of environmental change over time. In this way it advances to the practice of ecological economics, defined by Faber (2008) as the study of "nature, justice and time". Section 5.2 presents the geographical and historical background of Matadepera. Section 5.3 shows how private control of the town's water supply since the 1910s went hand in hand with the emergence of the lucrative business of vacation housing for rich urbanites. The struggle for the municipalization of water supply in the 1930s intertwined with the struggle for land reform. Both came to a violent resolution with the victory of Franco and landowning elites in the Civil War. Section 5.4 shows how in turn the fast and uneven urbanization of Matadepera in the 1960s and 70s built upon the highly concentrated ownership of land, which would not have been sustained without the repression of Franco's dictatorship. The historical record reveals a consistent pattern whereby subsequent waves of developers joined the water company to secure water for their projects, displacing costs to the future and the community through debts, increased prices and network under-investment. Section 5.5 relates the findings from Matadepera to debates concerning water, urbanization and policy.

This research forms part of the project "Memòries d'una feixa", a collaborative project of historians and environmental scientists from the region working to recover the historical memory of Matadepera. Most present-day residents were born or arrived in Matadepera after the Spanish Civil War. In a truly political ecological fashion the intention of this study is to reveal "all that struggle hidden behind the quiet vista" (Robbins 2004, xvi) and give voice to memories that, sometimes silent and sometimes silenced, are central to understanding the historical transformations of the Catalan and Spanish territory during the last century.

5.2. The political and ecological economy of 19th century Matadepera

Historically, land and economic power in Matadepera were extremely unevenly distributed. In 1886, just two family estates, the Barata and the Solà, owned half of Matadepera's territory. They, together with nine other estates, controlled more than 90%

of the land. Unlike other regions of Spain, the landlord class of the Catalan countryside did not descend from feudalism, but emerged out of the complex and conflictive transition from the medieval ages (Cussó et al. 2006), whereby a few farms accumulated pieces of land previously held under "emphyteutic contracts"[3] with feudalists (Garrabou et al. 2001). Between this landlord class and landless peasants stood 60 families who owned smaller plots and the remaining 10% of the territory.[4] The grand majority remained without property; that is 500 of the 574 registered residents of the town. Matadepera was not representative of the Catalan countryside, where generally property was more evenly distributed. It is particularly this uneven distribution of land and its maintenance through the control of vital resources like water and the exercise of brutal power that explains how Matadepera turned out to be today an elite suburb, unlike most other neighboring towns.

Matadepera is located in the hillside of the Sant Llorenç mountain, at an elevation of 423 m in the town centre. It has an area of 25.3 km^2 mainly covered with holm oak (*Quercus ilex*), mixing with Aleppo pine (*Pinus halepensis*) on the lower parts of the mountain. The climate is mild Mediterranean, Matadepera located in the semi-humid, north-eastern basins of Catalonia. The town's products in 19th century included cereals, livestock, olive trees and vines, lime, firewood and charcoal from oaks and timber from pines. Cereal and olive trees were grown for local subsistence and consumption. Some of the vine production was export-oriented (Roca 2003). Catalan vines benefited from high wine prices and reduced international competition after a phylloxera plague destroyed French vineyards in 1867 (Cussó et al. 2006). Still forest exploitation was by far the most lucrative business and totally controlled by the two land-barons of Matadepera, Barata and Solà, who owned the forest. The economy of Matadepera was integrated into the economy of nearby Terrassa, and to a secondary degree Sabadell and Barcelona (Fig. 1). The substitution of manual for steam engines turned Terrassa into the textile capital of Catalonia in 19th century. Terrassa's population quadrupled between 1830 and 1880 (Benaul 1998a, 1998b). Lime and wood from Matadepera were used in the booming construction of houses in the city. Firewood and charcoal heated the houses and moved the textile industries.

[3] Emphyteutic contracts, widely used until 19th century, granted the tenant use-rights over the land, as well as the right to alienate, mortgage and pass it to his heirs, in exchange for an annual payment and some services (Garrabou et al. 2001).
[4] Territorial tax, 1885–86, box 377, City Archives of Matadepera (CAM).

Tensions between landlords and peasants in the region mounted during the first third of 20th century. Reasons for this included technological innovations that enhanced labor productivity, ecological hazards, such as recurrent droughts and the phylloxera plague that hit Catalan vineyards around 1890, and unfavourable evolution of relative prices and competitors, such as North Africa and France vines (Pujol 1984). The duration of contracts between landlords and peasants and the distribution of product and inputs was mostly a matter of custom and convention but under the changing conditions, distribution of costs, benefits and risks became an issue of conflict (Garrabou et al. 2001). There were three types of contracts: sharecropping, where peasants shared between a quarter and a half of the crop yield with the landowner and contributed almost all factors of production; *rabassa morta* contracts, sharecropping arrangements specific to vineyards plantation, generally of longer duration and more difficult to cease, the tenant being responsible for planting the vineyards and cultivating them until the death of the stocks;[5] and daily wage labour, often paid in-kind rather than cash, common in forest activities and temporary farming tasks (Garrabou et al. 2001). With the crisis, peasants started laying property claims on the lands that they were using for generations based on customary agreements (Planas and Garrido 2006). Emerging forms of political representation included the *Unió de Rabassaires* (UR) founded in 1922. UR was a federation of 173 local organizations, the main trade union of the small peasantry, with 85,000 members in 1937 (Tébar 2006). The development of water resources in Matadepera unfolded within this context of struggle for land control (Fig. 2).

5.3. Water and land struggles in the first half of 20th century

The history of water is the history of the evolution of this town.
Jaume Riera, Mayor of Matadepera (foreword in Ametller 2002).

[5] It was particularly the duration of the *rabassa* contracts that became a point of content after the phylloxera plague. Landowners considered the agreement expired when the stocks died, while cultivators, who used to re-root the vine shoots to perpetuate the crop, claimed that as long as the stock was alive, the contract held.

5.3.1. Monopolizing water

Cereals or vines did not require much water, but water availability was vital for human settlement. Matadepera receives some 675 mm of rain each year (850 mm in the mountain peak), but it has no permanent surface sources (Martín and Moreno 1994). The main stream, Riera de les Arenes (hereinafter Arenes), is an irregular torrent, most year dry, bursting occasionally into extreme floods. Settlement along *camí Ral*, the road that connected Barcelona with Manresa (today high-street Sant Joan), started in 1768. A demographic explosion in the region increased the numbers of landless farmers, who could no longer be housed within the old *masies* (homesteads) (Garrabou and Tello 2004). Landowners with property around the *camí Ral* subdivided part of their estates and leased plots to peasants to build their home-shacks. They constructed water ponds for them, while the tenants took over the maintenance. Some tenants also constructed cisterns or drilled wells in their houses (Ametller 2002). By 1826 the new town had 35 new houses and 94 by 1861 (Ametller 1997). Domestic water use remained meager at 1–2 lpcd (Ametller 2002).

Water became an important resource as the demand for settlement started growing. In the 1890s wealthy individuals from the nearby cities started building houses in Matadepera to spend their vacations. Newcomers included intellectuals attracted by the beauty of the place and rich bourgeois advised by their doctors to escape from the polluted city to the clean and dry air of Matadepera. This trend of "back to nature", at least for the summer, was integral to an emerging movement of Catalan nationalism tied to romantic urbanite longing for wild nature and rural tradition. The first Catalan hiking club expedition to the Sant Llorenç mountains was organized in 1878. Its members walking the Matadepera path marveled in the "wild and manly nature…, this Catalan land so large and beautiful…that made us all feel proud to be its sons" (Arabía 1888). Fervent nationalism coupled with bourgeois environmentalism found their expression in the *La Renaixença* cultural movement. Journalist Pere Aldavert, a leading figure of *La Renaixença*, was one of the first and most prominent vacationers in Matadepera. He built a house in Sant Joan Street in 1890, and passed summers there with famous dramatist Àngel Guimerà (Duran 2006).

Josep Arnau was the first local who saw a business opportunity in real estate for holiday-makers and who realized the importance of mobilizing and controlling three crucial environmental factors of production – land, water and energy – in order to succeed in this new economic activity. Josep Arnau was son of a landless peasant who settled in Matadepera in 1858. Josep broke class barriers and accumulated money through a successful lime operation. He invested his profits in land with an intention to subdivide it and develop houses for vacationers. Arnau chose his property strategically: at the left bank of the Arenes, his piece of land included the only well in the vicinity of the village with a good water yield. Arnau was one of the local town bosses[6] and he was appointed mayor by the Monarchist authorities in 1891 and in 1902. Behind his rhetoric about providing a public service to "resolve the village's water problem" were his business plans to profit; not only by selling water, but also by selling land with water to vacationers (Ametller 2002). One of his acts as mayor was to grant himself the permit to build a tank of 100 m^3 to store water from his well and construct asphalt pipes to transport it to the town. A second system was developed in 1914 following the discovery of water by the priest of the village in a property alongside Arenes. Arnau provided the capital and together they founded "Aguas de Matadepera S.A." (hereinafter Aguas), the enthusiastic priest promising shareholders a minimum 6% return on investment (Ametller 2002). New pipes were laid down to the town and to the future estate developments of Arnau. Importantly, Arnau revolutionized water production by bringing to the town electricity and substituting manual with motor-engine pumping increasing water yields. Matadepera was electrified by a foreign multi-national, the Canadian capital-owned "Barcelona Traction, Light and Power Ltd", the first company to produce energy with fossil fuels in the region.[7]

In 1919, Arnau dissolved Aguas passing its infrastructure, minus the well, to the town Council. Water revenues from the poor peasants in the town centre were probably not sufficient to pay for operational expenses and Arnau and partners, having secured water, wanted to displace the financial burden.[8] However, only five years later, Francisco

[6] Local town bosses (*caciques*) were often some of the bigger landlords, lawyers, or even priests who held mortgages on small farms. During the 1st Spanish Republic, caciques controlled electoral results and made sure that the narrow interests represented by the system were never threatened (Preston 2006).
[7] The "Canadian", as the company was known by locals, is remembered today more for its role in the violent repression of the 1919 workers' strike in Barcelona (Termes 1987: 300).
[8] The archival record does not permit us to reach a conclusion on the terms of this agreement between Aguas and the municipality. It is not clear whether Aguas was indebted when transferred to the

Arnau, son of Josep, got the system back from the municipality, as he was planning a new, more ambitious urban development. Francisco was member of *Unión Patriótica*, the political organization with which dictator Primo de Rivera replaced the banned political parties. Primo de Rivera rose in power in 1923 with the support of the Spanish King and the caciques of the countryside, in a context of intensifying tensions between landlords and peasants. Francisco Arnau became councilor in the *Unión*-appointed town Council and head of the *Sometent*, a paramilitary group of 40 vigilantes, armed by the landlords to protect "public order", that is, discipline dissenting peasants. The appointed Council gifted back to Arnau for free the infrastructure of Aguas and the indefinite right for its use. Arnau proceeded in the first major urbanization project of 14 new houses, along what was named after his father *Passeig Arnau*, in the northern fringes of the then-existing town. His partner Josep Valls managed construction. All but one, houses were sold to bourgeois from nearby cities creating the so called "*barri* of the rich" (Ametller 2002: 22). Arnau, who was also the most powerful councilor, could in effect set water prices without public control. He charged water cheaper to his rich vacationing clients than to the peasants in the village. The few summer vacationers were consuming more water than all the rest of the town.[9]

Controlling the *Sometent* and the town Council, Arnau was powerful enough to prevent competitors from entering the local water business. When Ramon Codina, an industrialist from Terrassa, bought property and drilled new wells in the other bank of Arenes, Arnau complained directly to the provincial authorities and challenged him legally.[10] Although Codina had the most plentiful water source in the area, he ended up supplying only a private industry in Terrassa (Ruiz et al. 2008). This private monopolization of water and the fight between the landowner elites for controlling water was not unique for Matadepera but a general feature in Catalonia during the first third of 20th century (see Masjuan 2007; Planas 2004).

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municipality or whether Arnau sold or gave the system for free. We have reasons to suspect that the agreement must have been beneficial to Arnau as in latter correspondence and when the town Council was claiming its property of the infrastructure, Arnau son never objected.

[9] We infer these from a letter of Arnau to the Council in 1935, where he claims that the sale of water to vacationers yielded the same profits as the sale of water to villagers, though he supplied more water to vacationers. Francisco Arnau to Council, 20 August 1935, box 1073, CAM.

[10] Francisco Arnau to Civil Governor of Barcelona, 14 February and 21 May 1926, box 854, CAM.

5.3.2. Public vs. private. The short-lived republican alternative

In the 1930s, water and territorial conflicts in Matadepera were swirled into the mayhem of Spanish politics. A main cause for the Spanish civil conflict was the fierce resistance of the landed oligarchy to reform (Preston 2006). A coalition of republican centre-left parties won the 1931 Spanish national elections that followed dictator Primo de Rivera's resignation and prompted the King's exile. In Catalonia, ERC (*Esquerra Republicana de Catalunya*), a left-wing party directly linked to the *rabassaires* movement, held an overwhelming victory. Lluís Companys, leader of ERC after 1933, was one of the founders of the *Unió de Rabassaires*. Labour and land reform were at the core of the republican agenda. ERC and UR envisioned a Catalan countryside of small, landowning farmers organized in cooperatives (Planas and Garrido 2006).[11] A preliminary republican Regional Plan[12] foresaw a balanced development for the Catalan countryside. Farmland was considered national wealth to be protected. Industrialization and urbanization were to be balanced with agriculture and forest protection. Although urbanization was planned, large portions of land that were later to be urbanized in Matadepera and its surroundings, were designated by the Republicans for natural parks or farmland (Ribas 1995: 124–125).

Republicans elected 5 of the 7 councilors and the Mayor of Matadepera in 1931. One of the first acts of the Council was to set forth the municipalization of water supply. The Council refused Arnau an increase in water prices[13] for the first time and announced an open tender for augmenting the municipal water supply.[14] Arnau abstained and Ramon Codina, the industrialist from Terrassa who had sources in the other bank of Arenes, won the tender. Yet, without Agua's distribution network, Codina's sources were useless. The Council informed Arnau about "the date when he should quit using the pipes owned by the town Council",[15] i.e. the pipes that Arnau Senior passed to the town,

[11] The anarchist project, represented by trade unions such as the CNT, promoted instead the collectivization of land (Tébar 2006). During the Civil War the two projects, Republican and Anarchist, coexisted and competed in the countryside of Matadepera and Terrassa and there were conflicts between farmers from each side (Memories of Isidre Font Pi, 1975, unpublished manuscript transcribed and supplied by his son Francesc Font).
[12] The plan was entrusted by the Catalan Government to the architect and town planner Nicolau M. Rubió Tudurí in October 1931 (Ribas 1995: 116).
[13] Francisco Arnau to Council, 20 August 1935, box 1073, CAM.
[14] 11 April 1932, Official Bulletin of the Province.
[15] Council agreement, 6 June 1932, box 854, CAM; Mayor to Francisco Arnau, 21 June 1932, box 854, CAM.

only for his son to take them back for free by the dictatorship. Arnau claimed that the Council should then indemnify him for his own, older part of the network and the infrastructure of Aguas he developed after the transfer.[16] The town Council could not buy Arnau's part of the system and decided in the meantime to start taxing Arnau for the use of the public network.[17] Arnau petitioned to increase water prices to cover the new tax, a request refused by the Council.[18]

There are good reasons why public control of water was crucial for the Republican project. First, private real estate developments, such as this of Arnau, were turning farmland into urbanized land, displacing sharecroppers and *rabassaires* out of lands they used for generations. Republicans wanted to stop gentrified urbanizations. In a move full of symbolism, the Republican Council of Matadepera renamed "Arnau Street" in the "*barri* of the rich" into "Lluís Companys Street", the much despised by the elites, *rabassaire* leader of ERC.[19] Water was a powerful means for controlling urban expansion and a vital resource for the Republican vision of a small farm-based, balanced territorial development. Second, private monopolists changed water prices at will with no accountability for their profits. Rich holiday-makers paid less than poor peasants, while water supply in the town centre remained meager, most investments going to the satisfaction of new developments. The Republican agenda was to correct such injustices in the countryside and take away the power of the caciques. But municipalizing water was not easy as private interests, such as Arnau, had appropriated de facto in the previous years many groundwater resources.

Reforms came to a halt in 1933, when a right-wing coalition won the Spanish national elections. ERC and Companys were in power in Catalonia though; in 1934 the Catalan Parliament approved an agrarian reform law that granted *rabassaires* and sharecroppers the right to own the land they were cultivating (Planas and Garrido 2006). Landlord elites and their association of agrarian employers (*Institut Agrícola Català de Sant Isidre*) fought fiercely the reform. The conservative Catalan party *Lliga* that expressed their interests challenged the law in the Spanish Court of Constitutional Rights,

[16] Francisco Arnau to Council, 30 June 1932, box 854, CAM.
[17] Agreement of the Council plenary, 8 July 1933, box 1002, CAM.
[18] Commission of neighbors to Council, 16 August 1935, box 1073, CAM; Francisco Arnau to Council, 20 August 1935, box 1073, CAM.
[19] Agreement of the Council plenary, 28 July 1934, box 1002, CAM.

controlled by the right-wing. The court declared the law unconstitutional (Preston 2006). The Catalan and Spanish governments agreed on a watered-down version of the law, which nonetheless prompted an internal crisis within the right-wing coalition, catapulting the entry of three fascist ministers in government. Trade unions and the socialist and communist parties called a general strike for 5th of October. Lluís Companys declared a Catalan State and *Unió de Rabassaires* took control of wine-producing counties. In response, the military besieged the Catalan government palace, closed down the parliament and imprisoned Companys and his ministers. Republican controlled town Councils were dismissed and substituted by military appointed administering commissions.

The commissions were set to reverse the reforms of Republicans and restore the old order. In Matadepera, the military appointed as Mayor Josep Valls, the real estate partner of Arnau and one of the two *Lliga* councilors of the previous administration who opposed the agrarian reform. Valls cancelled the municipal contract for a public water supply[20] and Arnau resubmitted his petition to increase water prices. Caciques' manipulations however, now met resistance. A group of left leaning residents filed a formal complaint about Arnau's "abuse … for the sake of personal profit" and the unfair "distribution of costs among residents and vacationers".[21] Arnau responded aggressively questioning the political motivations and water business knowledge of the group and "welcoming" them to obtain water for themselves if they could, and offer it in "free competition" to the town.[22] Some of the authors of the complaint and the owners of the bar where it was written would face the wrath of Franco's dictatorship a few years later.

5.3.3. Civil War and the violent resolution of Matadepera's water and land struggles

On 18th July 1936, and several months after the victory of a Republican left coalition in the Spanish national elections, General Franco declared a military rebellion. Franco's supporter troops were defeated in Barcelona and other Catalan cities with the intervention of trade unions. Unions took the situation in their hands declaring a revolutionary state. The dark side of the revolution was the violence committed by

[20] Agreement of the Council plenary, 19 October 1935, box 1002, CAM.
[21] Commission of neighbors to Council, 16 August 1935, box 1073, CAM.
[22] Francisco Arnau to Council, 20 August 1935, box 1073, CAM.

mostly uncontrolled groups. Catholics, industrialists, landowners and other suspected Franco sympathizers were arrested and executed without trial. Antònio Barata Rocafort, the biggest landlord of Matadepera and former member of the board of directors of the *Institut Agrícola*, was arrested in Terrassa the day after the insurrection. He was executed by the end of August together with his brother, who was arrested in the family estate in Matadepera. On 24th July 1936 eight men were found dead in the forest north of the Barata house, most of them prominent members of the *Lliga*. Among them were Francesc Salvans, a banker and owner of the largest wool industry in Terrassa and of the most luxurious vacation residence in Matadepera loathed by locals for its extravagant parties. In October, Josep Valls, ex-mayor and business partner of Francisco Arnau was murdered near the town centre. Landowners and other right-wing sympathisers hid in the forest or abandoned Matadepera for Barcelona or for territories controlled by Franco. Francisco Arnau was among them.

The abandoned estates were settled by refugees, lucky to flee the territories occupied by Franco's army who murdered left-wing sympathizers by the thousands (in comparison to the uncontrolled violence in Republican territory, Franco's army deliberately planned mass executions to terrorize resisting populations elsewhere and to clean the territory from dissenters to his future regime; Preston 2006). Matadepera's town Council confiscated the forests of Barata and Solà, which provided a vital source of income during the war period[23] and workers collectivized the lime kilns of Arnau.[24] Food was grown in the gardens of the occupied estates. Water was provided by Arnau's confiscated wells and water tanks or bought from private wells of landowners that did not flee.[25]

Franco and his troops arrived victorious in Catalonia in January 1939. Matadepera and surrounding cities were bombarded for days without mercy (Interviews #1, 5, 10, 15). Refugees flooded the French border. Lluís Companys and his government fled to France where they were arrested later by Gestapo, extradited to Spain and executed by Franco. Landowners such as Arnau returned triumphant in Matadepera together with Franco's army recovering their confiscated lands and resources. The commanding officer of

[23] Agreements of the Council plenary, 19 June, 5 and 17 July 1937, box 1002, CAM.
[24] Collection of the committee for workers control of the lime kilns, 1937, box 517, CAM.
[25] Contract of the Council with Aldavert sisters to use the water from their well. Agreement of the Council plenary, 11 September 1937, box 1002, CAM.

Terrassa appointed an administering commission in Matadepera passed later to the main taxpayers of the town. Francisco Arnau was first deputy mayor and his nephew mayor. Arnau saw his charge for the public network reduced by 50% and prices increased at last to what he was asking for.

Occupied Catalonia experienced "an all-pervading terror … violence against the defeated not limited to prison, torture and execution but extended to the psychological humiliation and economic exploitation of the survivors" (Preston 2006: 311). The appointed municipal commissions were entrusted to issue reports concerning the political beliefs and activities of arrested republican soldiers and political prisoners. In Matadepera twenty people were imprisoned[26] and six sentenced to death, four of them implicated without proofs in the murder of Josep Valls. Accusations for those sentenced to death included the burning of the church (which actually was never burned), membership of the communist party, or the exploitation of private forests.[27] Prisoners and sentenced to death included some of the authors of the petition against increasing water prices. The telephone and tobacco businesses of the bar frequented by left-wingers, where the letter against Arnau was written, were confiscated and given to the widow of Josep Valls. Indicative of the reigning terror, even today, decades after the fall of Franco's regime, N. R., whose father was executed, preferred during our interview that we don't record her memories out of fear.

[26] Among them were the first Republican mayor of the town who was described in the Commission's report as a "man of left-wing ideology (who) during the Glorious National Movement … did nothing in favour of the Holy cause" (Mayor to Military Court, 23 February 1940, box 1075, CAM). He could be sentenced for life, but was lucky enough to be cousin of Arnau and go out after only one year. Isidre Font, ERC member and secretary of the agrarian trade union during the war, and among the authors of the letter against Arnau, was imprisoned in Terrassa for 2.5 years.

[27] Joan Martí, one of the authors of the letter against Arnau, was among those sentenced to death, primarily for his role in "the burning of the church" (Council report, without date, box 1075, CAM). Vicenç Vergés, "who was in charge of tree logging" of the confiscated forests (Council report, without date, box 1075, CAM), and allegedly helped in the search of Franco sympathisers hidden in the forests, was executed in Barcelona on the 4th of July 1940. Together with him was executed Jaume Ramon, councilor of the town and member of a communist party, described by the Commission as "one of the main Marxist elements" (Council report, 21 April 1939, box 1075, CAM; Execution files, box 1678 (3/3), Prison of Barcelona *La Model*).

5.4. Water in the service of elite suburbanization

5.4.1. Erasing the past, clearing the ground for the future

"See these fields, these vineyards and these mountains. Some day you will see them full of nice streets and villas. A lot of people will come. This town has a great future". And his eyes sparkled with the conviction with which he talked.
Priest of Matadepera Jaume Torres (Ametller 2002: 95).

With peasant dissent silenced and the Republican alternative defeated, the landowning elites of Matadepera could transform the territory according to wish or more precisely, profit. The dictatorship appointed town Council held a tight grip on the population. After the war, most families were left with "grandparents and children. Some had died in the war, others had escaped to France, and those who had not escaped were imprisoned" (Interview #1). Once back, prisoners had to report twice a month to a "Local Board of Freedom" (abolished only in 1955). The Council administered the rationing of food supplies imposed under the Franco regime of "autarchy"; dissidence was not an option. Franco's dictatorship consolidated the unequal distribution of land and put an end to demands for reform. The tax records of 1944 show an almost unchanged distribution of land compared to 1886.[28]

The urbanization of Matadepera was – and still is – perceived as a spontaneous process driven by the good climate of Matadepera that attracted holiday-makers. In reality it was a well-planned and executed socio-ecological project. Francoist authorities spelled out explicitly their vision for Matadepera in the Urban Plan of 1951: "Matadepera…given its geographical conditions…calls for the assignment of a signal-function: a place for resting and summer vacations".[29] Compare this to the vision in the Republican plan emphasizing the importance of "agriculture for our own food supply" and the quest "to not sacrifice all agriculture, forests and rivers" (Ribas 1995: 123). In the new era ushered by Franco, elite interests united and left aside rivalries under the protective wings of the dictatorship and the Church, whose role was crucial in legitimizing the new

[28] We infer this from the rustic taxes, which can be considered an approximation to the land distribution, 1944, box 24 (2AA), CAM.
[29] Plan de Ordenación de Tarrasa y Matadepera, 1951, p. 225, box 540, CAM.

regime. Codina and Arnau overcame their old feud and joined powers and capital, refounding Aguas de Matadepera in 1943, capitalizing on each' infrastructure (Ametller 2002: 36).

This transformation would not have been possible without the violent dispossession of peasants. Ametller (2002) states that the new urbanizations occupied vine "wasteland" abandoned due to phylloxera (p. 51). However, from oral sources a very different story emerges. Magdalena Font, niece of Isidre, remembers that "only few owned the land and they sold the entire thing for second residences. We were all sharecroppers. We had nothing of our own and they forced us out from everywhere. That was about it." (Interview #8). One of the last sharecroppers of the estate Gorina remembers that: "we did nothing and they kicked us out from our home… The owner told to my father 'it does not matter whether you have a contract, it is useless'" (Interview #7). Oral *rabassaire* or sharecropping contracts were swept in face of the lucrative real estate business. "Houses are houses", told a landowner and mayor of the town at the time to one of our oral sources, when he forced his family out of the land (Interview #7). Developers expelled families from lands they were working for generations. The dispossessed moved as labor to the Terrassa and Sabadell industries, often owned by their new rich vacationing neighbors in Matadepera. Others lived by the crumbs of the holiday-making economy working in services or as building workers, carpenters, painters, gardeners and domestic cleaners. As another interviewee remembers: "my father had the contract with the estate… and then, when they wanted to urbanize, they told him 'Joan, you will be the security guard and you will have a salary'. They had already taken the entire garden, and then my father died of a heart attack." (Interview #4).

New villas sprung in the 1940s and population doubled in the summers. A two-tiered society emerged consisting of the destitute peasants in the town centre, and the rich gentry passing luxurious summer holidays in their villas. As one interviewee recalls "in winter the town was a cemetery… [but] in the summer months the gentlemen of Sabadell, Terrassa and Barcelona came for their vacation. They had very good years. We didn't.… The worker had to work many hours to survive. The bourgeoisies, the rich of that time, yes, they spent very good years" (Interview #1). One year in the summer feast of the village (*Festa Major*), when supposedly all residents come together to party,

the holiday-makers installed their own tent. As an elder remembers: “they did their own summer-party … They did not want to mix with smelly sweaty people like us” (Interview #1).

5.4.2. Enrolling water in the transformation of the territory

The extreme concentration of land property in Matadepera meant that, compared to other towns in the Catalan countryside, unusually big plots were available. These were sufficiently big even after sub-division to develop luxurious villas. Hence lay the ecological–economic origins of the particular evolution of Matadepera into an elite suburb. Throughout the 40s, 50s and 60s rich industrialists from Terrassa, Sabadell and Barcelona, ploughed surpluses from the booming textile industry into real estate in places like Matadepera. Jaume Serra, a major developer in Matadepera and later president of Aguas (1967–1976) was such an industrialist who by the time he arrived in Matadepera in the early 60s, had already an expanding real-estate business in Sabadell and nearby towns.

There was “a clear link between the repression and the capital accumulation that made possible the economic boom of the 1960s”: trade unions were destructed and the repression of the working classes ensured starvation wages (Preston 2006: 313). Developers were the victors of the war. Pilar Prat for example, a prominent developer in Matadepera in the 60s, was the daughter of Agustí Prat and widow of Gaietà Vallès, both industrialists executed in the forest events of July 1936.

Developers learned the hard way that groundwater within their plots was not sufficient to irrigate their housing projects. Water was a crucial commodity in the real estate development process. Ametller (2002: 50) summarizes this succinctly: “without water, housing developments were not possible. Plots could only be sold as long as enough water was available… Soon those lands would acquire a much higher value”. The first wave of developers in the late 1940s self-organized to bring water from river Llobregat, via the infrastructure of Mina de Terrassa, which was since 1943 importing river water to Terrassa. A Commission of 66 stockholders was set-up to invest the capital and construct a canal to connect Matadepera to Mina's system. Stockholders included well known bourgeois families of the time. Only 8 of the 66 stockholders were residents of

Matadepera. 39 were from Terrassa, 9 from Sabadell and 9 from Barcelona.[30] The water transfer was intended to satisfy vacation housing and real estate development not local needs.

With its connection to the Llobregat River in 1949, Matadepera was connected to the water supply system of metropolitan Barcelona and integrated in the national hydro-politics and Franco's project of transforming the territory through a series of grand hydraulic works (Swyngedouw 2007). The Commission capitalized its Llobregat investment into Aguas. Aguas was refounded in 1949 to accommodate the new players. Arnau and Codina, both deceased, gave their place in the land and water business to the developers represented in the Commission. With water secured, its members proceeded swiftly to start their housing projects (Ametller 2002). The vision was clear: in a letter dated 2nd January 1951, the new President of Aguas, Àlvar Vinyals, thanked the town Council for its "clear vision of the future" and its political support for bringing water from Llobregat, a project crucial "for the supply of the old town and mainly [for the] housing developments that have been created or that are being created…Not only the current needs of the population will be fulfilled, but also those that in the future may arise … as Matadepera strives to realize its potential as a real holiday-making place".[31]

It is important to recognize that Matadepera was not naturally water scarce. The Codina and Arnau sources at their peak supplied 600 m^3 of water a day (Ametller 2002). For the 600–800 permanent residents of Matadepera in the late 1940s this meant that there were about 750–1000 lpcd potentially available. Even if it was less in dry periods, this is an abundant source of water. Yet consistently, from Arnau to the new developers in the 1940s and 1950s, the elites of Matadepera referred to the "water scarcity problem of the village", as if it was a generalized problem for all. Arnau for example in letters during his fights over increasing water prices claimed that he was contributing to the fight of "people" against scarcity.[32] Similar references to scarcity were made by Aguas as late as 1967.[33] However, Matadepera had more than enough water to satisfy the basic needs of its residents. Local water was scarce only for the expansion of the holiday-making economy and the subsequent (sub)urbanization.

[30] List of stockholders, Comisión traída de aguas a Matadepera, December 1947, box 854, CAM.
[31] Board of Aguas to Council, 2 January 1951, box 854, CAM.
[32] Francisco Arnau to Civil Governor of Barcelona, 21 May 1926, box 854, CAM.
[33] Advisor of Aguas to Mayor, 9 February 1967, box 854, CAM.

After the Commission, subsequent waves of developers joined Aguas to gain control over water and the urbanization process. When Jaume Serra entered real estate and Aguas declared an inability to supply the water needed for his planned schemes, he bought the majority of stocks of the company, financed a reservoir and a canal for his extensive urbanization and then capitalized it into Aguas stock, before becoming president of the company. Real estate and control of water went hand in hand.

By mid-1960s the urbanization business had become so lucrative that it attracted for the first time Matadepera's land baron, Antònio Barata. When his father and uncle were murdered in the events of 1936, newborn Antònio, heir to the dynasty, was hidden by his mother and they escaped to Paris returning only after Franco's victory (Interview #16). Antònio took over the family estate which with hundreds of hectares of forests, profited from firewood and charcoal sales. By the 1960s and as fossil fuels out-competed forest products, urbanization became an attractive alternative given the vast territory owned by Barata. In 1964 Antònio Barata requested water from Aguas for his prospective urbanizations. Aguas refused since its quota from river Llobregat did not suffice to supply Barata's gigantic plans (Ametller 2002). Barata placed a bid to buy Aguas, but its President valued it twice what Barata was offering. Barata was not used to hear no in his backyard from the authorities of Matadepera whom he treated as his subordinates.[34] Infuriated, he went ahead and developed his own water system, buying wells in Matadepera and drilling new wells in his territory that extended to adjacent basins and transferring the water to his Matadepera urbanizations. When a new well from Barata diminished Agua's supply from the old Codina well in Arenes, Aguas and Barata went to the Courts. So did Serra with Barata, fighting over the rights of trespassing of their infrastructure – water pipes and roads – from each other's lands. But these inner feuds between elites, quickly gave up in front of the common interest of business and money. In 1966 Barata and Serra/Aguas reached an agreement that regulated their respective uses of water and demarcated their service areas, the one promising to transfer water to the other, when needed. The agreement was signed

[34] Indicatively we found a 1971 letter classified curiously in the City Archives, sent by Barata directly to the Mayor's personal office in Terrassa. The letter concerns data requested by the Treasury of Barcelona for the size and features of housing developments for taxation purposes. Barata asked the Mayor to consult him first before sending anything signed to the Treasury. It is important, he wrote, to "give as little data as possible". The dictating tone of Barata in the letter and the fact that he sent it directly to the Mayor's personal address and not the town hall illustrated the intimate relationship of Barata and municipal authorities (Barata to Mayor, 29 April 1971, box 385, CAM).

symbolically in the town's Summer Feast, villagers supposed to celebrate the collaboration of their two patrons (Ametller 2002).

All these urbanization schemes transformed radically the landscape of Matadepera. In 1964, 26 houses were being constructed, 36 in 1965, 20 in 1967 and a minimum of 139 between 1971 and 1975. The urbanized area increased from 37.6 ha in 1956 to 180.3 ha in 1984 (and 357.9 ha in 2008), sprawling from the town centre towards the north in former fields and forests (Fig. 3) (Estany 2008). Second residences became first residences and permanent population rose from 730 (1955) to 1075 (1970) and 3493 (1986). Environmental and social impacts were dramatic including loss of landscape heterogeneity and biodiversity, destruction of the traditional built environment, youth migration due to high cost of life, and the disappearance of the rich peasant heritage (Badia et al. 2008; Estany et al. 2008a; Comasòlivas 2004; Otero 2005; see also chapter 4).

5.4.3. Privatizing profits, socializing costs

While developers were pocketing the huge surpluses from real estate, they were charging losses on the community. A consistent historical pattern emerges whereby subsequent waves of developers joined and controlled the water company to secure water for their projects, displacing costs to the future and the community through debts, increased prices and distribution network under-investment. Arnau Senior started this pattern with the water system for his first housing project that he passed back to the townwhen the business was no longer profitable, only to get it back when he and his son were ready for the next urbanization scheme. Similarly, the transfer of water from the Llobregat in 1949 permitted the partners of the Commission to realize huge short-term profits by the re-valuation and sub-division of their lands. Having secured water, one by one became disinterested in the water business. Yet the costs of increasing water consumption were only later realized. Aguas agreed with Mina to pay water from Llobregat on a volumetric basis. The Commission secured access to water and did not care about the future cost. But as consumption volume increased dramatically in the following years, so did the charge that Aguas had to pay Mina. Prices increased to cover Aguas losses and debts, in effect spreading the cost of water for the urban developments to the whole of the community. Water price increases were politically contentious.

Since the 1950s Aguas used a multi-tier tariff with lower rates for permanent residents and increasingly higher to holiday-makers and luxurious uses such as swimming pools and lawns. Price increases were thus relatively smaller for permanent residents, but still a grand portion of costs they were asked to pay related to the extension of supply and network to satisfy newcomers. In 1957 the town Council approved a petition by Aguas for a 25% rise in the water bill,[35] but refused to do the same two years later, when Aguas asked again money for a new water tank and to buy more water from Mina "for the watering of gardens and the use of private pools, i.e. an increase in consumption due to the numerous recently built villas".[36] In 1967 Aguas declared big losses and asked for a new increase in price, although a new rise had been granted in 1964.[37] Residents organized and in a letter to the town Council, 16 individuals protested against the proposed prices[38] and the poor maintenance and dilapidation of the network.[39] Indeed, the network was losing big quantities of water (Ametller 2002). The extremely dispersed pattern of urbanization in Matadepera meant that network development and maintenance were relatively expensive. Underinvestment – in the design or operation phase – was an indirect way of reducing these costs, but came at the expense of high costs in the long term due to pipe bursts and water losses.

The town refused Aguas a 31% price increase asked in 1971. To show its power Aguas refused to supply water when in the Summer Fiesta of 1972 the Council was going to inaugurate a public fountain (Ametller 2002). In 1974 and 1975 Aguas declared big losses, attributing them to increasing demands and water purchases from Mina. However, an anonymous memo in the City Archives, most likely written by an engineer of the Council, questions the credibility of the figures given by Aguas, pointing to a "voluntary" – in effect, mandatory – contribution which the company charged to new connections and which was not declared in its books. The memo argued that Aguas was not having losses, and that the price petition aimed to increase profits.[40] However, Aguas continued complaining about its dire financial situation and in 1976 threatened

[35] Advisor of Aguas to Mayor, 27 April 1957, box 854, CAM; agreement of the Council, 15 May 1957, box 854, CAM.
[36] Advisors of Aguas to Mayor, 1 July 1959, box 854, CAM; Mayor to advisors of Aguas, 22 August 1959, box 854, CAM.
[37] Advisor of Aguas to Mayor, 20 and 29 December 1964, box 854, CAM; advisor of Aguas to Mayor, 9 February 1967, box 854, CAM.
[38] Residents to Mayor, 22 April 1967, box 854, CAM.
[39] Mayor to Aguas, 31 March 1967.
[40] Anonymous memo, without date (around 1972), box 854, CAM.

the town with liquidation and ceasing its activities. The mayor of Matadepera, Josep Mas, stepped in to become the new president of Aguas replacing Serra who resigned. Four town councilors joined the Board of the company. Prices were then increased in 1976, 1977 and again in 1979 at the relief of Aguas' shareholders who saw profits restored.

Franco was dead by 1975 and since 1979 Matadepera was governed by a democratically elected Council. A popular movement of environmentalists from nearby cities and parties of the left achieved the first major blow against unfettered urbanization of Sant Llorenç del Munt forest. In 1982, an area of 9600 ha was declared a protected natural park, stopping Barata's expansive housing projects (Interview #17). Nonetheless, the population of the town grew 4 times between 1970 and 1990 as vacation homes turned into permanent suburban housing. Wealthy newcomers were attracted by the exclusiveness and elite status of Matadepera. They settled in old villas or built new ones in undeveloped plots. The municipality controlled Aguas, and in effect subsidized growth, keeping prices low, and paying for major new investments. To reduce the expenses of the company, the municipality itself sold water below cost to Aguas from its own wells (Ametller 2002: 80). The private shareholders of Aguas were officially subsidized by the public burse.

In the 1990s, Aguas became integrated in regional and global flows of water, land and capital. In 1987, the municipality capitalized company debts into municipal stocks. An extraordinary 10% dividend to shareholders was paid next year. With finances sanitized, in 1992 Mina de Terrassa, which already owned some Aguas stocks, bought the shares of the deceased Jaume Serra, and became majority shareholder of Aguas, owning 70% of its stocks. Mina, now called Aigües de Terrassa, is in charge of the distribution of water in the city of Terrassa and other surrounding towns. Aigües de Terrassa is part of the international conglomerate Aguas de Barcelona (Agbar), one of the biggest private multi-utilities in Spain, comprising of more than 150 companies, with operations in Europe, Africa and Latin America (Masjuan et al. 2008). Agbar itself is majority owned by the French multi-national Suez and the Spanish savings bank La Caixa. Agbar and Aigües de Terrassa have several real estate subsidiaries. One of the first actions of the new directorship of Aguas in 1993 was to sell to developers its high-value land property in Matadepera, including the old plot of Arnau (Ametller 2002: 86). Being part of

Agbar, the water company of Barcelona, and receiving water from the Ter–Llobregat river system, Matadepera is now an integral component of the metropolitan water system of Barcelona, that has undergone several water crises, the last one in Spring 2008.

5.5. Water scarcity, social power and the discourse of progress

Private detective Jake Gittes (actor Jack Nicholson) asks aged millionaire Noah Cross (actor John Huston) about his conspiracy plot to steal water from farmers for his urban development in Los Angeles:
– "Why are you doing it? How much better can you eat? What can you buy that you can't already afford?"
Noah Cross replies:
– "The future, Mr. Gittes, the future."
From the film Chinatown (1974).

The story of robbing the destitute of the earth of their water to give it to the rich in the name of solving scarcity and delivering progress has been told many times and in connection to capital accumulation and urbanization (Gottlieb and Fitzsimmons 1991; Swyngedouw 2004; Worster 1985). The most famous case remains this of Los Angeles and the Owens Valley (Kahrl 1982), which inspired the film Chinatown. What is this article adding to this narrative?

First, simply telling the story in a context for which it has not been told (Spain, Barcelona), if not silenced, is important per se, more so since such a critical narrative does not appear to have made headways in Spanish water policy debates, still structured along the lines of spontaneous demands and natural scarcity. The interrelationship between social power and water policy has only recently started to be investigated in Spain (Swyngedouw 1999, 2007); our account hopefully offers a local complement to national scale accounts.

Second, and more importantly, the empirical validity of the "water robbing story" is currently questioned from revisionist historians with different accounts of water controversies in the American West (Erie 2006; Kupel 2003; Libecap 2005). The fact

that the story seems to hold in a very different geographical, historical and socio-political context, a small town in Catalonia, is important. It suggests a more generalizable pattern relating control of water, dispossession, and urbanization.

However, more than this, the Matadepera story offers material for a stronger rebuttal of revisionist arguments, in the process improving understandings of the relationship between social power and water. The revisionist argument has two components which we will oversimplify here taking Kupel's (2003) work on water and urbanization in Arizona as an example (Kupel himself frames his work as a disproof of the water robbing-social power thesis of Gottlieb and Fitzsimmons 1991 and Worster 1985). The first is that the thesis of undemocratic hydraulic elites controlling water to serve their ends is at best, representative of only a few places, and at worst a "conspiracy theory" (Kupel 2003, p. xix). For Kupel the municipal leaders in Arizona were not busy devising pet projects or manipulating prices, as critical scholars argued for their counterparts in southern California (Gottlieb and Fitzsimmons 1991). Instead, they struggled to respond to the demands placed on the water system by an ever-increasing number of residents and to "find diverse solutions to water scarcity to achieve the realization of an urban vision" (p. xvi). Public opinion in Arizona, Kupel argued, was always in favour of developing water; water was vital for settling the desert and making life there as comfortable as in the humid environments from where settlers migrated.

The second line of rebuttal is based on the notion of progress. It goes basically like this: ok, maybe the poor were robbed of their water, but let's forget it as everyone got better at the end. In Arizona's water history Kupel sees universal progress with corrigible environmental side-effects: living conditions, material comfort and incomes improved and there is nothing to be sorry about. Ametller's (2002) amateur history of water in Matadepera is very similar. Matadepera was a dry and poor place and it fell upon great men, like Arnau or Serra to develop water resources. Ametller, a priest of left leanings active in the resistance against Franco, does not hide that Arnau and his likes profited more than they deserved along the way. But overall, in his view, "progress has a price and it must be paid" (Ametller 2002: 52 and interview #9). Depictions of monolithic elites conspiring to control water may be sometimes (though not always) simplistic. Yet Kupel's rejection of the "elite thesis" and his counter-story of "leaders" responding to the will of free subjects is overtly naïve. In Matadepera, the violence perpetuated by

Franco and landowners against peasants over the control of land and water, speaks for itself. One might counter-argue that little changed in the way water and territory were managed after democracy. Yet, as this history showed, the basic contours of choice in the democratic period were defined through violence in the Francoist period. Once Matadepera was entrained in an elitist (sub)urbanization path, this was very hard to reverse. Still, someone might also contend that ours is an outlier case, in an undemocratic society (Franco's Spain). Kupel for example is at pains to demonstrate that in Arizona, citizens did vote in favour of urbanization and water development. However, as Swyngedouw (2004) and other political ecologists have argued, representative democracy is not without faults. Elites exert power not only through violent coercion, but also through their ability to achieve spontaneous consent of non-elites through the control of opinions and ideas (Kaika 2005; Nevarez 1996). Powerful interests can strategically use and manipulate discourses – language, stories, images, models, concepts, terms – to serve their goals. This does not – necessarily – imply conspiracy; less visibly, power-contingent discourses get naturalized through social processes into taken-for-granted ideas that in turn reinforce the powers and institutions that created them (Bakker 2000; Kaika 2005; Nevarez 1996). Scarcity and progress are two such important discourses of legitimization of power in Matadepera.

Water was not naturally scarce in Matadepera. It was technological, energy and political scarcity that impeded accessing local groundwater in early 20th century. Once accessed, groundwater was enough for residents' needs. Yet water became scarce again because of the water intensive holiday-making and suburban economies. There was nothing "natural" in this scarcity insofar as the social change that produced it was not natural. Matadepera did not have to become a holiday resort for the rich; it became so through intense political and social struggles. Arnau and Aguas, repetitively referred to water scarcity as a natural and collective problem of Matadepera positioning themselves as the leaders in charge of solving it technically. No mention that this problem of scarcity was an outcome of their urbanizations. Even today, Ametller (2002) writes that Matadepera is a "dry place" and that "scarcity is a constant in the history of the village" (p. 11). And this is still the prevalent view among many residents, in a town surrounded by lush forest and with one among the highest levels of water consumption in Europe! The discursive construction of a natural scarcity is so powerful that defies even experienced reality.

Our interviewees, even those who suffered from Francoist repression or those critical of environmental and cultural degradation, excused such grievances in the light of progress. Progress is seen as both undeniable and inevitable. Scarcity plays an important discursive role as the antithesis – the enemy and proof – of progress. In the words of Ametller: "In reality the town has become a new town…all this wonder of progress has been possible thanks to water (…) Let's pray to God that the flow of rivers is maintained and increased everyday" (2002: 97). Progress becomes equivalent to more and more water. In turn, everything that comes with more and more water is by definition a progress erasing, if not justifying, past injustices.

Like scarcity, the notion of an undeniable progress can be questioned. First, progress in material consumption might have been bought at a cost that is still to be paid. The energy and capital necessary to drill water out of Matadepera's soil were produced through the burning of fossil fuels that today threaten to destabilize climate and change life in Matadepera and the rest of the planet. Forest fires are becoming more catastrophic as a result of urbanization and changing land-uses. And Matadepera's model of urbanization-based growth turns out to be economically unsustainable. Matadepera's town finances find it hard to sustain the city's expansive and expensive infrastructure. New urbanizations, the main source of municipal taxes, came to a halt due to the crisis in the housing sector, more so as there is no more land to urbanize. Second, progress can mean different things to different people as there are different visions of the "good society" (Norgaard 1994). This multiplicity of visions is suppressed in accounts like Kupel's or Ametller's who assume a singular "urban vision" (Kupel 2003, p. xvi), namely increasing material affluence. The Republicans for example had a very different vision for the Catalan territory, prioritizing different values and possibly distributing affluence differently. We know very little about this alternative vision; historical research about environmental and resources policies in the Republican era is at its infancy. We can also only speculate about the evolution of the Republican project in the Cold War era. Nonetheless, it suffices to make the point here that there was an alternative vision of progress and that Matadepera's present state as an exclusive elite suburb was not inevitable. Yet rendered inevitable, the discourse of a universal progress, serves to erase not only injustices, but also the presence of alternatives and alternative values. The question is not whether society got more materially affluent or not while developing water resources. The question is whose

vision of the future came to be realized and whose vision (and livelihood) to be erased. Unfortunately in Matadepera, like other places, it is largely the vision of the Noah Crosses of this world that shaped the world we experience today.

Our account therefore enriches the "water robbing" story by showing that what was robbed was not so much – or not only – water, but the ability to shape the future. And that the means of robbing were not only political decisions and guns, but also pervasive discourses about scarcity and progress. The political ecological perspective used here, benefiting from the methods of environmental history, is a useful complement to ecological economics, which, with few notable exceptions (Martinez-Alier 2002), has neglected social power and injustices in the course of socio-environmental change and continues to treat nature as inherently scarce, an external limiting factor to society. Political ecology sees society and nature as intertwined, the one conditioning the other and in the process co-producing new natures and new social arrangements. In return, ecological economics offer to political ecology the important insight that there are multiple, irreducible visions of progress (Norgaard 1994) and multiple languages of valuing progress (Martinez-Alier 2002). Environmental policy from a political, ecological–economic perspective becomes then primarily a question of environmental justice; justice in having a say over the shape of the future and justice in the distribution of the goods and bads of change (Martinez-Alier 2002; Norgaard 1994; Swyngedouw 2004).

In Spain today, there is a popular social movement opposing hydraulic expansion and arguing for a "new water culture" (Estevan and Naredo 2004), based on democratic management of water and an alternative model of balanced territorial development (Aguilera Klink 2008). In Matadepera, citizen groups fight to stop encroaching urbanization, protect the forest and secure a future for the less well-off residents of the town. Hopefully our narrative strengthens their case that there is an alternative and helps them shape a different future than this envisioned by the Noah Crosses of the region.

5.6. Figures and tables

Figure 1: Location of Matadepera. Source: own elaboration.

Figure 2: A chronology of Matadepera and its history (1902-2008). Source: own elaboration.

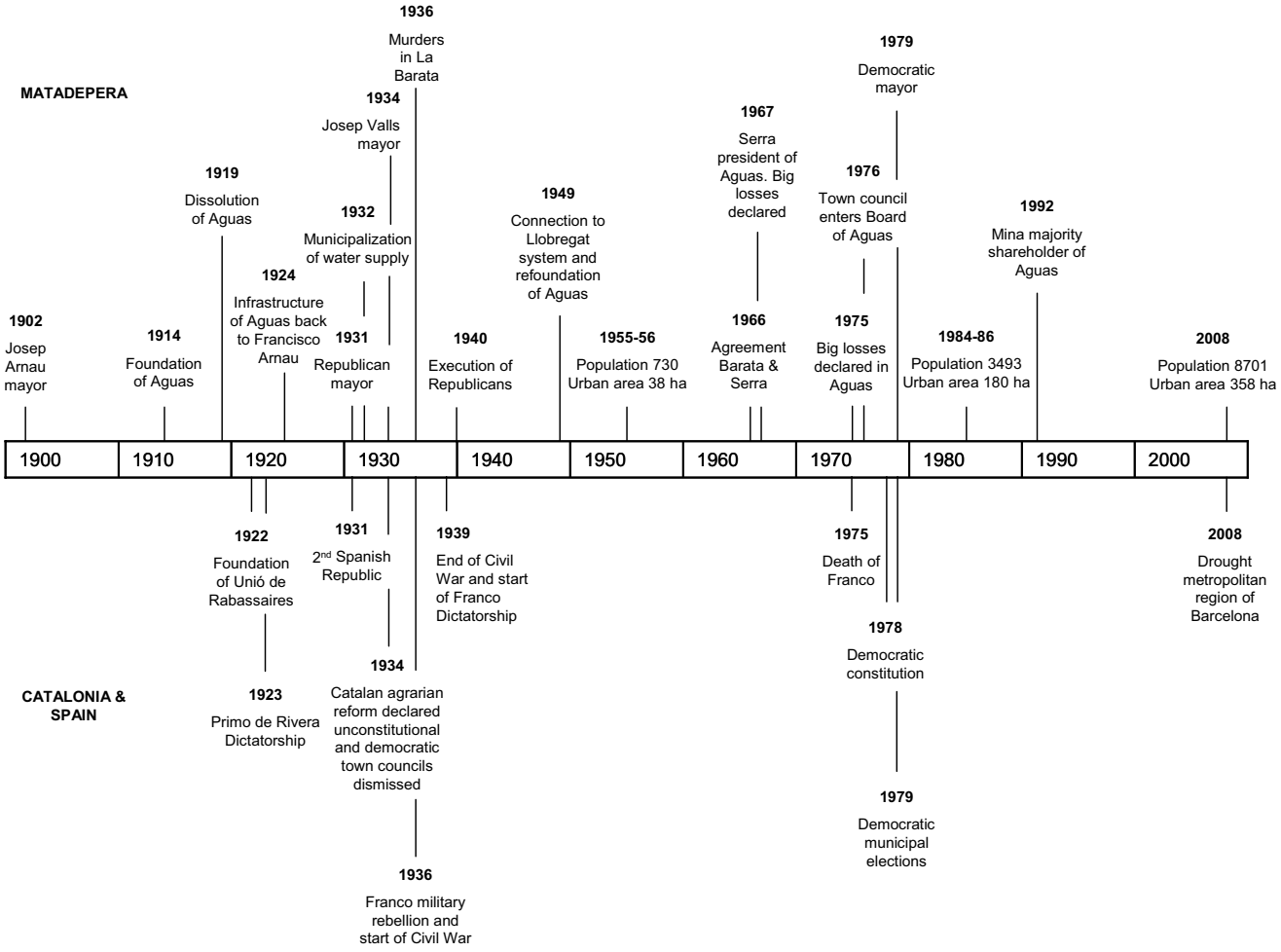
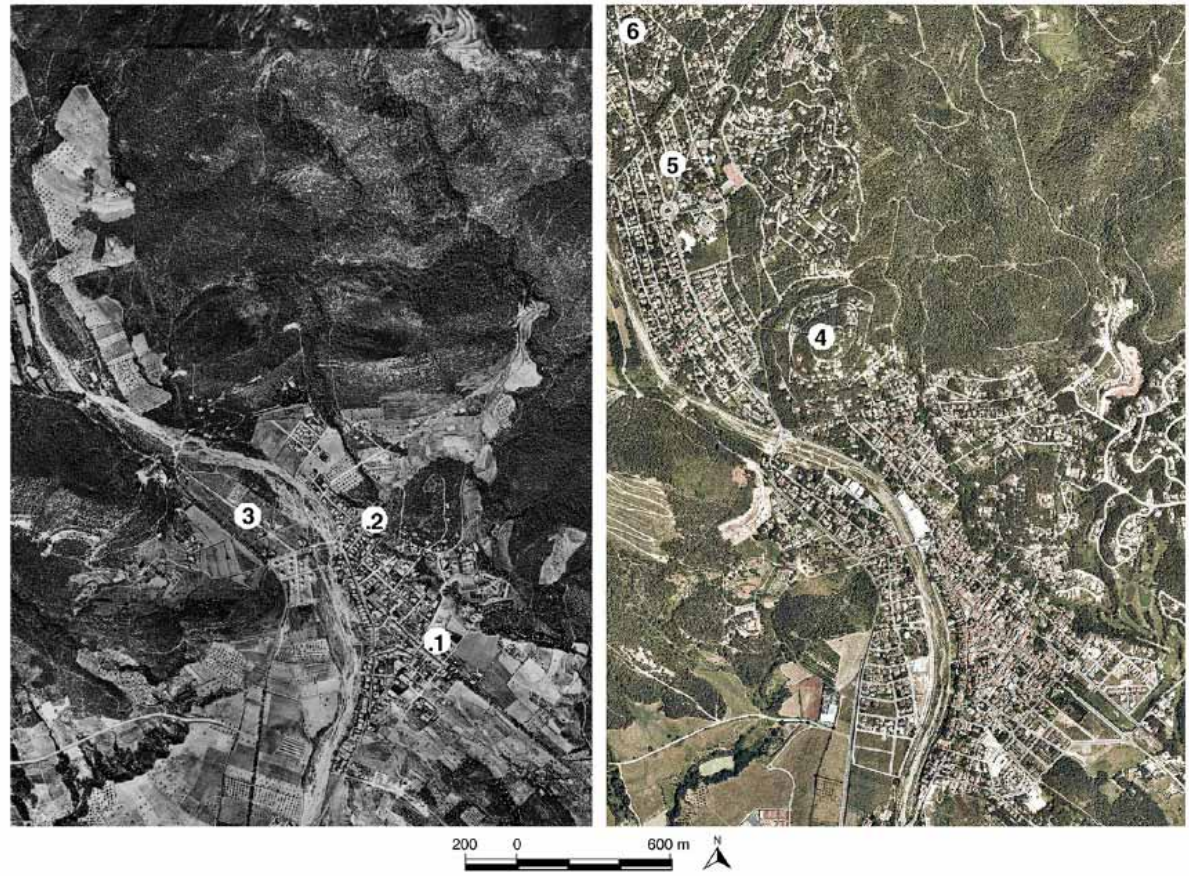


Figure 3: Aerial photographs of Matadepera. Left photo from 1956 shows the compact town centre and the incipient urbanization in the surrounding fields (US Army, 1956). Right photo taken in 2004 shows urban expansion to the north-west and east (Institut Cartogràfic de Catalunya, 2004). In this period, urban area increased from about 38 ha to about 358 ha. 1) St. Joan Street, former *camí Ral*; 2) Arnau Street; 3) Development of one of the main stockholders of the Commission to connect Matadepera to Llobregat River; 4) Development of Prat; 5) Development of Barata; 6) Development of Serra.



6. CONCLUSIONS

6.1. Rural-urban socioecological transformation in Olzinelles and Matadepera

The analysis of the productive system of Olzinelles and its historical roots (chapter 4) has shown the particular way in which this mountain area entered the specialization path of the Catalan countryside from the 18th century (Fontana 1990). Unlike the coastal area, engaged in a wine specialization, the low availability of arable land in a mountainous relief and the consolidation of a highly uneven private landownership arising from the transition from feudalism to agrarian capitalism promoted the early specialization in forest products. The role of Olzinelles as provider of forest energy and materials (charcoal, firewood, timber, cork) for the growing industrial Barcelona city was strengthened with the arrival of the railway in 1860. Although in the second third of the 19th century, when wine prices rocketed, the wine specialization arrived to Olzinelles, it never attained the importance of the more agrarian municipalities of the coast and the Vallès Oriental County (Planas 2003). With the arrival of the phylloxera plague in Olzinelles and the abandonment of the vineyards by the tenants, the *rabassa morta* contracts allowed the landowners to recover the wasteland, which could be reforested or afforested again.

Several practices allowed the social-ecological system in 20th century Olzinelles to adapt to the changing external demand while keeping its capacity to supply food to the local community: use of a high specific and intraspecific diversity for livelihood security and for commercial options; management of integrated agrosilvopastoral systems at different spatial scales with strong interdependences between productive activities in terms of matter and energy and a careful manure allocation; paramount role of forests, with several productive layers (canopy, trunk, shrub, herbs and roots), and the coppice selection system. These practices were the result not only of local ecological knowledge, but also of hybrid knowledge from the landowners or State foresters that studied in the University. The practices were embedded in a particular institutional and cultural settings and worldviews that provided flexibility to reorganize under changing circumstances, as it has been attributed to other indigenous and rural communities of the world (Toledo et al. 2003; Berkes et al. 2000). It also could be concluded from chapter 4 that strategies to use the resources in a sustainable manner have emerged in a context

where private landownership has been consolidated during the last centuries. However, it has been clearly shown the highly uneven landownership structure and the social inequalities that it promoted.

The social-ecological system of the old municipality of Olzinelles and its creative life forms have been dramatically transformed during the last decades of the 20th century as a consequence of a national-to-global process of modernization. The "rural membrane" that provided food, energy and other goods both to the local population and to external markets is now mainly devoted to administrative nature conservation, residential developments and leisure activities such as trekking, mountain cycling or hunting. Josep Travesa, one of the main characters of chapter 4, told me intrigued: "I can not understand where the wheat is grown, now. You go to Barcelona and you do not see wheat anywhere. And you think to yourself: so much bread is thrown away! So much bread is thrown away!" So the wheat now may be imported from "around Andalusia or America". Indeed, food, energy and other materials are brought from more and more remote peripheries of the centers of the world-system, though this has not been analyzed in our research.

Regarding the developments, one could ask why Olzinelles did not become an elite suburb like Matadepera, given that political economy of both areas was quite similar by the end of the 19th century, with an extreme concentration of land property almost covered by forests where unusually big plots were available to develop luxurious villas (compare sections 4.3 and 5.2). As shown in chapter 5, the path of elite suburbanization in Matadepera was early chosen at the end of the 19th century. The dry climate, the beauty of the place, and the closeness to the growing industrial cities of Terrassa and Sabadell explain the arrival of the first rich vacationers. Later, the power of landowning elites to control land and water after the Civil War and the particular institutional and legislative setting under the Francoist dictatorship, together with a global context of industrialization and agricultural abandonment (Estany et al. under review) explain the transformation of Matadepera into an elite suburb. The rich holidaymakers in Matadepera were not living in extremely congested peripheries of the city cores, so the extreme urban density can not explain by itself the demand (and supply) of second residences (Catalán et al. 2008). By the end of the 19th century no industrial areas as important as Terrassa and Sabadell were located near Olzinelles, and the demand for

upper class vacation houses might have been absorbed by other towns closer to Barcelona city (Cardedeu, La Garriga) or even by the northern Montseny towns (e.g. Viladrau) where rich people went to "make health" (*fer salut*) attracted by the high quality of mineral waters. However, further research is needed to clarify this.

What has been clearly shown is that the abandonment of a diverse set of agrosilvopastoral practices of adaptive management has resulted in a decrease of species from fields, meadows and sparse forests in Olzinelles and, in general, in Montnegre mountains. Land abandonment and migration of peasants to the urban centers resulted in a biocultural degradation of the cultural landscape that is now to be preserved by administrative measures, as it has happened in many other areas worldwide (Reyes-García 2008; Gómez-Baggethun et al. in press). Although forest cover has clearly increased, land abandonment has proven here to have a radically different outcome than in the cases reported by Grau and Aide (2008), where ecosystem recovered after people left. It could also be concluded that forest recoveries at local scales in Mediterranean mountain areas are not necessarily good per se but rather the conservation of particular taxa from open habitats should be taken into account. Considering that cropland in the BMR are diminishing at a high rate due to urban sprawl (Catalán et al. 2008; Paül and Tonts 2005) and that they play an important role in the conservation of cultural landscapes, especially in homogeneously forested mountain areas, its conservation and enhancement should be one of the priorities of the regional planning system, as it has also been stated by different works (Marull et al. 2010; Pino et al. 2000).

At the catchment scale (Olzinelles valley, chapter 3) we can conclude that the lower runoff response to rainfall may be attributed to a drier period rather than to the small afforestation experienced in the last decades. The afforestation of fields experienced between 1956 and 2002, which represents 4.2% of the catchment area, was probably too small to have a significant impact on water runoff, though in the first half of the 20th century, when higher depopulation and afforestation rates occurred (especially after the abandonment of vineyards affected by phylloxera plague, as noted above), the effect on water runoff might have been visible. Changing climate would seem thus to be explaining the reduced RR, with no substantial interaction with land-use changes.

Although the initial hypothesis in chapter 3 has not been demonstrated, the results may be highly interesting for decision makers and Park managers concerned for the relation between decreasing water resources and forest growth. In the case of Montnegre-Corredor Park, a program to remove forests and plantations from former fields so as to recover the stream runoff from the catchment has been planned and implemented in Olzinelles valley. According to our results, the recovery of former agrarian cover in order to partially compensate the effects of climate decreasing the runoff would not have a significant effect on runoff unless large forested areas were converted into fields or pastures, something that must be carefully evaluated in terms of the opportunities and the trade-offs with other ecosystem functions and services, such as the conservation of open habitats and their biodiversity, as mentioned above, or the prevention of wildfires.

Mediterranean forest hydrology is particularly complex and has some specific features that need to be taken into account to fully understand the relation between climate changes, land-use changes and hydrological changes. Contrary to the commonly assumed idea that a thinner forest would result in a higher water runoff, under Mediterranean conditions, i.e. potential annual evapotranspiration exceeding annual precipitation, the increased throughfall after thinning will be transpired by the remaining trees at an increased individual rate, improving their water status, without becoming stream flow (Gracia et al. 1999; Piñol 1991). However, future studies should incorporate the variation of canopy cover in the land-cover classification and in the simulation given i) its potential role in the rainfall interception and partitioning processes, which is still poorly understood by hydrologists especially within the rainfall and vegetation conditions of Olzinelles catchment (Muzylo et al. 2009; Llorens and Domingo 2007), and ii) the great increase in canopy cover experienced in the catchment as a result of the abandonment of forest management practices.

The disappearance of some aquatic and semi-aquatic species from the stream has been documented and related to the observed decrease in water runoff. The fact that some of these species have small distribution areas and that their overall population is declining, together with the expected increase in aridity, leads to think that the (total) drying up of small (intermittent) streams from mountain areas should be considered together with the other factors accounting for the general decline of these species, namely stream degradation, water pollution and construction of dams in the case of fish species

(Aparicio et al. 2000); habitat alteration, overexploitation and crayfish plague in the case of white-clawed crayfish (Gutiérrez-Yurrita et al. 1999); and degradation of the aquatic ecosystems in the case of water vole (Arrizabalaga and Montagud 1989).

The decrease of animal and plant species both from the stream and from fields, meadows and sparse forests come to add to the recently reported effects of land-use and climate changes in the biodiversity of this region, namely: phenological alterations in abundant plants and birds (Peñuelas et al. 2002); northward shifts in geographical ranges of butterflies (Parmesan et al. 1999); negative impact of agricultural intensification and urban development in butterfly populations (Stefanescu et al. 2004); upward shift of beech forests and replacement by holm oak forest at medium altitudes (Peñuelas and Boada 2003); and naturalization of exotic species (e.g. Douglas Fir, Broncano et al. 2005). These studies stress the effects of climate change and intensification of land use on biodiversity, i.e. show that some human activities have a clear negative impact. In the present thesis, the negative impact on biodiversity does not result from wrong and increasing human activities but from the disappearance of good activities for biodiversity conservation. In this sense, it agrees with Bartolomé et al. (2005), who show how the cessation of traditional controlled burnings by shepherds has promoted encroachment by shrubs and expansion of forest to the detriment of more diverse grasslands and heather (*Calluna vulgaris*) pastures of European conservation interest.

Chapter 5 shed light on the political and power struggles that lay behind the rural-urban socioecological transformations such as those analyzed in previous chapters, this time focusing on suburbanization. Processes of suburbanization are often explained through metaphoric narratives where expert technicians, enterprising businessmen and diligent politicians make a huge effort to overcome natural constraints to the development and the progress of the community. An example of this account is the local history by Ametller (2002), where a clear progressive plot shows how the dry and poor Matadepera of the beginning of the 20th century was transformed to a thriving suburb thanks to local enterprising men that managed to develop water resources and overcame the natural scarcity. In Ametller's work there are no conflicts between local people; the struggles for land and water reform and the Civil War itself are simply ignored. On the contrary, the analysis in chapter 5 shows clearly that different visions of the future by

different social groups (landowners, left-wing republicans) collided in the process of suburbanization. The detailed analysis of archival material and oral information allowed downscaling to the personal level, even to imagine how the characters of the story thought, felt and interacted. The socioecological project promoted by ruling elites prevailed because they were able to control vital resources like land and water with the annihilation of the dissidence through prison, execution and psychological violence under the new Francoist regime (Preston 2006). The discursive construction of a "natural scarcity" helped to achieve spontaneous consent for controversial aspects of bringing water to allow the gentrification of the town.

In the research questions (Section 2.4) I wondered how small and landless peasants have been affected by the process of suburbanization. Some of the oral sources were very clear on this point, as shown in chapter 5. The story of the sharecroppers of the estate Gorina being expelled from the house and the land they were looking after for generations by the landowner and mayor of the town at the time ("Houses are houses", he told them) could not be more illuminating. After his family being dispossessed, the son Mingo Comasòlivas was still young and wanted to work as a peasant. Since he was landless he had to rent a vineyard, farm it, make the harvest and produce some wine to be sold, which was by no means enough for the livelihood of his family. When the landowner of the vineyard wanted to urbanize he had to leave and look for another vineyard and so forth, until the last one was urbanized (Interview #7).

As when discussing the notion of socioecological heritage (see sections 4.6 and 6.2), it has to be stressed that the analysis presented so far does not intend to be nostalgic and offer a romantic view of the rural past since large inequalities dominated the socioecological relations. Rather, conversations with old peasants make clear that the broader processes of industrialization, agricultural intensification, rural-urban migration and urbanization (Ramankutty and Foley 1999; Stoate et al. 2001; MacDonald et al. 2000; Collantes 2007) are not the only and "natural" causes of farmland abandonment. And, more importantly, they reveal that suburbanization and landscape changes may be seen as better or worse according to different valuation criteria. Their particular experiences and memories have this incalculable feedback on socioecological change research. By giving voice to silent experiences this account hopefully offers a complement to the studies on land changes in the Barcelona Metropolitan Region

(Dura-Guimera 2003), especially those emphasizing how class and power relations legitimize some particular socionatures over others (Domene and Saurí 2007) or analyzing the relationship between water management and social conflicts (Masjuan et al. 2008). It can also be particularly insightful to agrarian histories of the town (Roca 1996, 2006) and the region (Roca 2008; Garrabou and Tello 2004), since it explains the end of the peasant communities studied by them.

However, if researchers must listen to "the myriad of voices of civil society and talking to them" (Guha 2002: 20) in an honest way, it has to be acknowledged that the story of peasants being dispossessed from their lands in Matadepera is not the only one emerging from the oral sources. As it has been pointed out, the expanding holiday-making economy increased the demand for services, building workers, carpenters, painters, gardeners and domestic cleaners, and the growing industries from nearby cities offered jobs that, though not being the best possible, were considered less unattractive than the not much productive dry land agriculture and forestry. As one of the locals remembers, "thanks to Matadepera's change, and I say that it has changed too much, my children have a painting business, and there are other business as carpenters, electricians... This village has been lively" (Interview #5). As opposed to Mingo Comasòlivas, who told me that indeed he would undoubtedly go back to the world of his childhood, his wife Magdalena Font, although she later explains the dispossession from their lands, said that she would never go back to her own past, and that "when working in a factory you had your wage guaranteed; however, when working on the land you did not (…) living from the land was like slavery" (Interview #8).

As argued in chapter 5, the question is not whether local people got more materially affluent or not while developing land and water resources. The first question should be whose vision of the future came to be realized and whose vision to be erased, why and how. This one has been answered so far. The second question would be whether the transformations experienced in places like Matadepera, with high social and ecological costs, can be characterized as progress. The inherited impacts and costs of the low-density elite housing have been clearly identified (Otero 2005): youth migration due to high costs of housing; no immigration of less well-off collectives and cultures; expensive maintenance of urban infrastructure and services (streets, pavements, lighting, water, garbage collection, public transport); high consumption of finite

resources (water, oil) and locally finite resources such as (fertile) land; increased human and forest vulnerability to wildfires; destruction of old tracks, lime kilns, springs, vineyard huts, farmhouses; loss of locally adapted crops, specially fruit trees; and lack of an alternative source to the urbanization-based model for municipal finances.

Denying the spontaneous nature of suburbanization, showing that it is not outside deliberate political choice, and proving that the elite suburb was not inevitable, strengthens the argument of citizen groups that are fighting to reverse the legacy of such an urban model and to lead the social-ecological system to a more desirable and resilient state (see the epilogue and section 2.3.6).

6.2. Interdisciplinarity, languages, and the otherness

Since global crisis is the result of non adaptive relations between humans and their environment, the research that is supposed to have a crucial role in helping to overcome such crisis must also be relational to offer appropriate solutions. This thesis combined approaches from both the social and the natural sciences to build a holistic view of land changes. Although apparently holism might mean a lost of detailed knowledge, and sometimes troubles to publish in peer-reviewed journals, the emphasis on the whole allows to capture emergent properties that would go unnoticed when reducing the system to isolated "objects" to be analyzed in detail (Capra 1998). In chapter 3 I integrated archival information, used classically in agrarian history and historical geography, with data on land-covers (geography), forest modeling (ecology); meteorological variables, and biodiversity monitoring. In chapter 4 the archival record was widened in sources and time frame and extensive use of semi-structured interviews through qualitative content analysis was made to explain the environmental history and the management practices of the peasant community. Extensive field work during the last five years, including countless hours of walking, observing and hearing, was vital to understand the historical socioecological relations in Olzinelles' system.

Chapter 5 was the result of 22 years living in Matadepera (see the prologue), where the ideas of "field work" and "participant observation" do not capture the whole experience. During all these years I have traveled across the municipality and Sant Llorenç mountains, I have slept in their caves and farmhouses and I have been trapped in the

thorny bushes when trying to reach a hidden objective. Despite all this effort, only a crumb of the mountain is known. The interviews used in chapter 5 were designed upon innumerable informal talks, excursions, meals and knowledge sharing with local elders, including a co-authored publication on the local knowledge of mushrooms with one of them (Garcia and Otero 2009, see fig. 1 from section 2.5). In the previous section it was concluded that the detailed analysis of archival material and oral information allowed even to imagine how people though, felt, and faced. But this extreme detail was possible also because I was part of the community under study and hence I knew and interacted for many years with some of the characters (both right-wing and left-wing) and their sons and daughters. This facilitated a lot the understanding of personal rivalries and opinions as well as the complex networks of relatives of the town.

Chapter 5 combined ecological economics, environmental history and political ecology, three hybrid disciplines which in turn are the integration of the study of nature with the study of different aspects of the human (Toledo et al. 2002). The environmental historical approach has deepened the understanding of land-use changes, as argued by Garrabou and Tello (2004) and Boada and Saurí (2002). The synergy between political ecology and land-change science stressed by Turner and Robbins (2008) has also been proven to be highly fruitful in the last case study. The so-called interdisciplinarity is thus possible, although some prerequisites are needed. The predisposition to understand the paradigms, languages and methods of the disciplines that are to be integrated and the ability to integrate them in an emerging language are two very important ones. The understanding of the other disciplines means, besides reading a lot of what is produced, to talk to, interact with, and understand how the colleague is thinking in relation to you and your approach.

Interdisciplinarity, as defined so far, is not enough. In the new relationship between science and society, non-scientific knowledge must also be connected with modern scientific knowledge (Gallopín et al. 2001). In the introduction I wondered how to include the experience of the eldest peasants without reducing it to numbers or mere anecdotes. Besides enriching my knowledge of the social-ecological system and its evolution (especially in chapter 4), some of their stories and claims have been incorporated into our account (especially in chapter 5) to refute histories based in progressive lineal narratives that forget the social and ecological costs of progress and

that conceive an only path of development for all kinds of societies (Guha 2002; Fontana 2000; González de Molina 1993). Naturally the voice of those who particularly suffered the transformations analyzed in this thesis, mainly for being small peasants in an urbanizing metropolis and for being (sons of) the losers of the Civil War, have been "amplified". It can be conclude that the environmental historical studies presented in this thesis (chapters 4 and 5) can be a good complement to historical studies aimed at creating an appropriate historical memory of this country (Cuesta (ed) 1998; Sevillano 2003). Most of the studies related to historical memory have focused on the workers' movement in big cities during the last years of the Dictatorship or on the Francoist repression in the postwar rural areas (e.g. Mir 2000). But between the urban cores and the rural areas (e.g. suburbanizing countryside) there is a historiographical gap that this thesis may contribute to fill (Ruiz et al. 2008).

We have proposed a notion of heritage that is based on socioecological relations, specifically on the management of integrated agrosilvopastoral systems at different spatial scales. Particular management practices as those described in chapter 4 have given character, distinctiveness, and ecological diversity to landscapes, but they are now no longer viable. This means that new management strategies should not try desperately to maintain or freeze traditional land-uses (Kurin 2004), but rather to lead the new social-ecological systems to the desired stability domains (Matthews and Selman 2006) drawing on such heritage, in a process of adaptive comanagement in which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning-by-doing for problem solving (Olsson et al. 2004). We think that considering some of the management practices of our ancestors as a legacy is a way to recognize the forgotten rural origin of our current culture. In an analysis of the sites of UNESCO's World Heritage List located in the EU member states, Van Gorp and Renes (2007) concluded that although most of European history has been rural, rural heritage is weakly represented, Europe presenting itself as an urbanized and Christian continent with a long history. Whose heritage and which groups are represented or forgotten are thus fundamental questions to select our relation with the past, as Guha (2002) puts it, and hence our identity.

Seizing invisible realities through their traces and imagining new ones. Otherness excluded from Modernity must be taken into account in an "environmental ethics-

aesthetics off-centered from the rational subject, towards the radically and absolutely strange: other cultures, other species, other living beings, other life-creating forms, *others*, in its most genuine sense" (Noguera 2007: 22). In the prologue I suggested that probably the central question is what we need to learn from 'the eldest' rather than from their 'knowledge'. Recovering personal memories and narratives that have been fragmented or erased (Nazarea 2006) may serve to make out alternative development paths and to reinforce action towards a more sustainable and inclusive mode of environmental production (Swyngedouw and Heynen 2003; Wallerstein 2007).

6.3. Hybridity and neutrality

The thesis tries to offer a balanced social-ecological perspective overall, but the chapters differ with respect to the degree of hybridity between the biophysical and the socioeconomic domains. Although in the introduction I argued that nature and society are not phenomenologically or scientifically distinct (Goldman and Schurman 2000), this is not always easy to translate into the analysis. So chapter 3 may be based on a "dualistic balance", i.e. an approach that acknowledges the importance of both set of considerations –the social and the biophysical- in a way that is intended to reflect balance but that views them as separate and distinct (Freudenburg et al. 1995) since it studied how the biophysical world (Olzinelles stream) responded to a change of the social setting (rural exodus and land abandonment).

Hybridity increases in chapter 4, although the fact that it refers to "socioecological interactions" suggests that a distinction between the social and the ecological subsystems has been presupposed. Chapter 5 tried to fuse society and nature through the process by which cities metabolize nature producing new urban socionatures (Swyngedouw 2004); articulating the natural as constitutive of the social and vice versa. To do so one has to choose i) the relevant facts and characters, ii) the starting landscape and the final landscape, iii) an appropriate narrative to link facts, characters and landscapes, iv) an appropriate language to valuate the new socionature produced throughout the narrated story (see Cronon 1992). All these choices are influenced by the personal context of the author and thus neutrality is not only impossible but also undesirable; it is often invoked by official histories intended to reinforce the power and the projects of the elites (Fontana 2002).

The thesis moves from historical (socio) ecology to historical political ecology (Davis 2009), although coining new terms to designate an approach that may not be as new as pretended may not be scientifically prudent (see section 2.3.2). As the thesis unfolds and hybridity increases, ethical neutrality decreases. Positioned research in chapter 4 makes way for a narrative in chapter 5 that, without loosing rigor, empowers our own fight to stop encroaching urbanization and protect the forest from wildfires in Matadepera (see the epilogue).

It could be concluded that a suitable combination of different degrees of socioecological hybridity may be suitable to understand the complex dynamics of land change and biodiversity conservation in a particular social-ecological setting, as well as useful to overcome the strict conceptual and analytical separation between society and nature; city and countryside; conservation and development; protected and non-protected areas.

6.4. New questions and further research

However, such complex dynamics deserve further research to answer new questions. With respect to hydrological changes, the need to understand the role of the canopy cover in the water cycle of Mediterranean forested catchments has been pointed out. More accurate simulations with GOTILWA+ model, including a previous calibration of the parameters with the measured data on water discharge, available for the Fuirosos catchment, would result in much more solid results for Olzinelles. The use of a simpler hydrological model with few parameters including the share of canopy cover –derived from a more detailed photointerpretation of the aerial photographs- could also shed light on this issue. Besides the effects on fauna species, the drying up of Olzinelles stream may be affecting negatively some plant species with aquatic requirements. Specific samplings conducted during the present work suggest that some phanerogams such as *Salix purpurea* and *Juncus bufonius*, reported by the botanist Montserrat in Olzinelles (1989, field work from 1949), may not be there anymore. A more specific methodology should be used so as to confirm these changes, as well as the increased mortality of alders (see section 3.2.1).

The influence of landownership structure on land-use and land-use changes is a question arising naturally from this thesis. The particularly uneven distribution of land

both in Olzinelles and Matadepera has to be evaluated in relation to the processes of land-change identified so far. The existence of a detailed archival record on agriculture and forestry taxes and on land distribution from the mid 19th century until nowadays and the experienced gained in Olzinelles allows investigating if this particular landownership structure has lead to specific paths of land-change with respect to other Mediterranean mountain forests (Otero et al. in prep). Moreover, the existence of a map on the land-uses of 1853 Olzinelles (Otero 2006: 84) might result in a cartographic analysis spanning for 150 years, as it has already been done by several researchers in Catalonia (e.g. Olarieta et al. 2008).

A particularly interesting question is how changing management practices lead to changes in biodiversity. This includes both the abandonment of the integrated management of agrosilvopastoral systems (Chapter 4) and the recovery of some of the old practices -grazing, thinning and ploughing- by the Park of Montnegre-Corredor so as to halt the loss of fields, meadows and sparse forests. After 10 years of butterfly monitoring in Can Riera de Vilardell (see note b from table 4 in section 4.7), in 2004 the Catalan Butterfly Monitoring Scheme moved this transect to Can Valls, in Olzinelles valley (see figure 1B in section 4.7), where the new conservation measures by the Park are being tested in a pilot project. By the end of 2010, seven years of data will be available and will allow knowing whether the new strategies based on old rural activities will have a positive effect on butterflies' populations.

From the research in Matadepera several questions arise, perhaps one of the most important being how is the on-going process of action-research contributing to the desired socioecological transformation. The process has to be critically analyzed and tested against the scientific peer-reviewed literature on action-research, socioecological transitions, and resilience of the social-ecological systems. Identifying some of the remaining pools of local ecological knowledge with important social and ecological functions is an essential step in the action-research process. The management of the expanding populations of wild boar (*Sus scrofa*) in Sant Llorenç del Munt mountains, for example, depends on the knowledge about the ecology and ethology of the species held by local hunters. The search for lost trekkers in the mountains by local firemen and ADF volunteers would not be possible without a detailed knowledge of the territory and place names. The qualitative approach used in this thesis to study the local knowledge

and the management practices may be strengthened, complemented or contrasted with the use of quantitative methods (Gómez-Baggethun et al. in press), which would require larger samples and thus would be an opportunity to widen the study area to the whole system of Sant Llorenç del Munt mountains and surroundings plains.

Another very important step to reinforce and empower those groups fighting for alternative futures is to continue the research on the political ecology of suburbanization. Besides the water issue, the history of forest management during the 20th century may be particularly illuminating. During the Civil War, the Town Council of Matadepera confiscated and managed the forests of the largest landowners. The sale of forests products provided a vital source of income for the Town Council and wages for the workers during the war period (Aguilar 2010). Forest-related businesses, such as some of the existing lime kilns, were collectivized by the workers during several months. Slashing of ground vegetation, coppicing, pine logging and charcoal making were managed by a public/collective body for the first time in many centuries of forest history in the region. How was the collective management of forest organized? Which practices were prioritized and why? How were the benefits from the sale of firewood and charcoal distributed among forest workers, businessmen, and the Town Council? How were the republican forest managers repressed by the local Francoist authorities?

7. EPILOGUE

Es sols lo començament
lo que prenías per terme.
L'univers es infinit,
per tot acaba y comença,
y ençà, enllà, amunt y avall,
la immensitat es oberta,
y ahont tu veus lo desert
exams de mons formiguejan.

From the poem "Plus Ultra" by J. Verdaguer (1905, p. 91)

When I came back from the Italian Dolomites, after the summer of 2003, the large fire of Sant Llorenç del Munt mountain had already been put out, but it was in everyone's lips. I was given the chance to lead the Local Environmental Council of Matadepera. We organized several round tables and conferences with local and external experts to debate how to face the threat of wildfires. The volunteers of the local Group of Forest Defense (*Agrupació de Defensa Forestal, ADF*) and the firemen stressed the need to manage fuel accumulating forests to reduce fire vulnerability. One of them, forest engineer of the Catalan Ministry of the Environment, was the bridge between the local knowledge of forests and fires and the expertise of the Catalan fire brigade's special unit on large fires (GRAF). A management scheme was prepared with joint work that combined fire modeling with forest planning (ADF 2005). The scheme, including mechanical thinning, slashing and crown pruning in about 100 ha of strategic areas regarding fire spread (Farriol et al. 2007), was approved by the Town Council of Matadepera and executed by general consent of forest landowners and the Natural Park.

In order to control sprouting and to keep a low fuel load in the thinned stands we promoted the recovery of extensive grazing of sheep and goats, one of the most important economic activities of the region throughout the last millennia (Roca 2008; Martín 2000). We the ADF reached an agreement with the main forest landowner (Barata's heirs, see chapter 5) to use an old farmyard of their own. We restored the

farmyard and offered financial, logistic, administrative and personal support to shepherd Paco from the Bages County to graze his flock in Matadepera's forest. In collaboration with pasture ecologists from the Universitat Autònoma de Barcelona a modest monitoring plan was implemented, where we measure the grazing pressure on plants and the effects of grazing on vegetation structure and chemical composition (Màdico 2009).

Some of the remnant fields in the municipality, both from the Town Council and private owners, are now ploughed and sowed to produce fodder and grain for the flock, ADF dealing with the management. Other fields are used by a sharecropper family to grow organic vegetables (Otero et al. 2007b). Extensive farming and grazing contribute to the conservation of habitats and species that motivated the designation of Sant Llorenç del Munt mountains as Natura 2000 site, such as Bonelli's Eagle (*Hieraaetus fasciatus*) (Zozaya et al. 2007; Ontiveros et al. 2004), and also other species and taxonomic groups not as media-friendly as the eagle but not less important: small mammals (Torre and Arrizabalaga 2000), butterflies (Muñoz 2006), and birds (Ballesteros and Degollada 2000).

The philosophy behind this management strategy is not to exclude wildfire but rather to build a more resilient social-ecological system, being able to absorb fire events and retain essential structures, processes, and feedbacks (Adger et al. 2005). The decrease of fuel load in strategic areas through different techniques is expected to decrease the intensity of fires, which is ultimately responsible for damage to life and property (Piñol et al. 2007). Our efforts have also been focused in stopping the encroachment of houses into the forests, since besides having direct negative impacts such as landscape fragmentation, destruction of heritage and high water consumption, vulnerability to wildfires is high and very difficult and expensive to manage by the Town Council. The narratives provided in chapter 5 and in Estany et al. (under review) have been used as strong evidence that we are now suffering the social and ecological legacies of the wrong choice of development path for Matadepera. In the NE of the town core about 239 ha of low forested hills (almost 10% of the whole municipality) remained free from urbanization but were threatened by real estate interests (Badia et al. 2008). The Local Environmental Council started a campaign to involve the citizenship in the protection of the area. Elders joined us. In one of the interviews from chapter 5, Pintoret told us "that

it is already enough of houses, enough of asphalt, enough streetlights, enough cars and enough curbs and everything. [In] Matadepera we have gone too far". With more than 1300 signatures and 18 local and regional bodies supporting the cause we asked the Town Council to protect the area from new developments. The plenary approved our proposal by general consent.[1] The area is now protected and managed to enhance its heritage, and might be included in the Natural Park in the future. Some examples are the restoration of several old lime kilns by a team of archaeologists coordinated by the Local Environmental Council, and the recovery of one well by the Town Council to have an additional supply during the water shortage in spring 2008.

Management practices, direct action and scientific research are combined with environmental education within the Local Environmental Council, including a Botanical Garden created in 2005 and a program of conferences, courses and guided trips done in collaboration with several local organizations and primary schools. The dissemination of the management strategy through conferences, our journal *Sotabosc*, and regular communications with the local, regional and national media helps to overcome the urban view of landscapes as pristine nature (Boada 2003) and achieve a harmonious reconciliation of diverse points of view (Ravetz and Funtowicz 1999). In a self-organizing process of action-research stemming from real-life problems, as insider scientists working together with the local community we produce knowledge that facilitates the socioecological transformation in the desired direction (Robinson 2008). Besides being fed back into the setting from which it emerged, the knowledge is expected to be shared beyond such setting (Herr and Anderson 2005). An effort is made to publish the results of action-research in local-regional journals (Ruiz et al. 2008; Otero 2005), in the proceedings of the Natural Park periodical meetings (Badia and Mira 2007; Farriol et al. 2007; Otero et al. 2007b), in national geographical journals (Badia et al. 2008; Estany et al. 2008a), and in international peer-reviewed journals (Otero et al. in press, see chapter 5; Estany et al. under review). In this way we contribute to the training of environmental scientists, either at the Bachelor's Degree (Màdico 2009), Master (Estany 2008), or PhD (this work) levels.

[1] Agreement of the Council plenary, 14 May 2007. Town Council of Matadepera.

The socioecological transformations studied in these work may be considered local outcomes of a global change promoted by an unsustainable economic growth rooted in an anti-adaptive culture. According to Ángel (1995: 116) “all cultures in their twilight dream of becoming sustainable”. But there is no exit within our existing worldview. In Olzinelles and Matadepera, although these changes have lead to an increased social well-being overall, inherited social and ecological costs and problems are enormous. In Matadepera, our town, we are engaged in a self-organizing process of adaptive action-research that draws on various knowledge systems and experiences to lead the social-ecological system to a desired and resilient stability domain (Folke et al. 2005; Olsson et al. 2004). This is a process of learning-by-doing in which new socioecological relations and institutional arrangements are to be build across multiple spatial and temporal scales. Knowledge is no more a building that has to be constructed upon the solid basis of normal science, but rather to emerge from a network woven without hierarchies (Capra 1998) in a radical and happy commitment to create a new existential territory (Escobar 1998) and an alternative, smaller economy, suitable to the physical needs of humans and ecosystems (Kallis et al. 2009). “Swarms of worlds are tingling”, felt the poet Verdaguer more than a century ago, when he longed for death to arrive and bring him to the absolute glory that was already making his skin tingle.

Before the 1930s no one in town could imagine the dramatic change it was about to come in Matadepera. Small actions may have large and unexpected effects on the whole system. Surprises may lead Matadepera to unimaginable states. This may sound funny in a suburb with high standards of living, high consumption of resources, and expensive cars with posh drivers. But the view of rustic shepherd Paco leading his flock to the pastures across the streets of the housing developments, and the sheep excreting naturally in the pavements of the luxurious mansions, fills me with hope.

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