Facing an Uncertain Climate: Interlinked Social, Ecological and Climate Changes Affecting Livelihoods in the Italian Alps and Apennines

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Abstract

Mountain areas are particularly susceptible to climate change. In the Italian Alps and Apennine mountains, average temperatures have increased, the intensity and frequency of precipitation events have changed, and the timing of the seasons has shifted. These changes are intersecting with on-going social and ecological changes and are, at local scales, felt to a greater or lesser extent by local people. In mountain areas, among those most exposed to the consequences of climate and associated environmental crises are smallholder farmers, beekeepers, hunters, and all those activities that depend directly on the climate, including tourism and winter skiing. The current chapter provides three case studies of how climate, social, and ecological changes are intersecting to affect these individuals and sectors and how they are facing and confronting the challenges. The examples reveal how the impacts of climate change are compounded by on-going social and ecological changes, how the climate crisis connects diverse actors at local scales while also bringing them into contact with global processes of change, and how human and non-human actors are connected by the impact of climate change on mountain ecosystems and weather patterns.

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1. Introduction

> "The seasons have changed!" (80-year-old male, beekeeper)

> "You see, at these altitudes [1300 meters] the snow is all gone long ago… flowers have already sprung up, snowdrops in the meadows, but it wasn't like this before." (55-year-old male, manager of a ski resort)

> "Everything in the Mont Blanc area is changing invisibly, the forest, the animals... they are no longer the same; even their eyes are different... chamois seem to cry". (64-year-old male, professional hunter)

> "That which has changed the most is the landscape […] because of the simple abandonment of the mountains by its inhabitants". (31-year-old female, farmer and beekeeper)

Each of the mountain residents quoted above identify climate and weather, ecological, and social changes affecting mountain areas in Italy. Temperatures have increased, the timing of the seasons has shifted, and mountain landscapes and ecology are different than they used to be (Copernicus, 2024; Monteiro & Morin, 2023). Climate, weather, and ecological changes have occurred alongside social changes, including rural and agricultural abandonment, the industrialization of mountain areas, a decline in services, and changing demographics (Dax et al., 2021; Plieninger et al., 2016; Tasser et al., 2017). The mountain residents – all dependent on the mountain environment for their livelihoods – also identify how climate, social, and ecological changes are affecting the deep interconnections between humans and the non-human in ways that have implications for the future. As they adapt to the interconnected changes they face, their ability to do so is shaped by these same changes, and by the mutual interdependence among humans, plants, and animals in mountain areas.

In this chapter, we describe how interconnected climate, social, and ecological changes are affecting those dependent on the mountain environment and climate for their livelihoods, such as smallholder farmers, livestock farmers, and hunters as well as those involved in tourism and winter skiing. We

describe the changes being observed and show how these changes intersect and may compound each other. And we show how the changes highlight and also affect the mutual interdependence among the human and the non-human in Italy's mountains. A key conceptual reference is the notion of eco-nostalgia (Albrecht, 2006; 2011; Angé & Berliner, 2014; 2020; Howe, 2020), which builds on the concept of nostalgia and extends it to encompass all experiences of ecological loss – mining extraction, nuclear accidents, water contamination, glacier melt, rising temperatures, and species extinction; all events understood as disasters that transform familiar, lived environments into estranged places. From this perspective, ecological damage renders it possible to lose the cognitive and affective anchors of a place without physically departing from it or being forced to migrate, thereby drastically reducing one's capacity for adaptation. Within cultural and social contexts, adaptation strategies emerge as complex historical processes – always negotiable and negotiated – and are shaped by the specific circumstances, opportunities, spatial settings, and temporal frameworks in which they unfold (Hulme 2009).

The chapter is organized around the experiences of individuals living in mountain areas of Italy, specifically the Alps (the Val Camonica and Valtellina in the Lombardy region and the Mont Blanc area in the Valley of Aosta) and the Apennines (Garfagnana area of the Tuscany region). We present their experiences and observations alongside the results of natural science studies that document phenological, cryospheric, and other ecological changes. We present three case studies that show how intersecting changes are affecting hunters, winter tourism operators, and people involved in agriculture, specifically beekeeping and livestock and crop farming. The first case study examines the impact of increasing average temperatures on the relationship among hunters, chamois, and the plants on which they both depend. The second case study shows how changes in the quantity, nature, and distribution of snowfall is affecting the winter tourism sector. The shifts in winter snowfall are also affecting agriculture, the focus of the final case study. The tourism and agricultural sectors are increasingly interconnected by the issue of water and its absence. Farmers and beekeepers also report changes in average temperatures, precipitation patterns and intensity, and the phenology of flora and fauna. These changes intersect with social changes to affect the survival, productivity, and profitability of farming and beekeeping in the mountains.

The case studies provide insights into how people living in the mountains are thinking about, framing, and responding to change, and how the way they do so is shaped by and shapes their relationship to the mountain environment and the non-humans with whom they share those environments. In the face of challenges to their livelihoods, mountain residents are adapting and identifying new paths forward.

2. Background

2.1 Climate Change in the Mountains

Over the course of the 20th and 21st centuries, average temperatures in mountain areas have increased faster than the global average in the northern hemisphere (Copernicus, 2024; Rogora et al., 2018; Monteiro & Morin, 2023). Higher temperatures have caused ice and snow in the mountains to melt, decreasing the albedo effect. As a result, Alpine glaciers have shrunk to their lowest levels in two thousand years; in the summer of 2023, the zero-degree isotherm broke two records, reaching 5328 meters in the Alps when on average it should be around 3500 meters (Copernicus, 2024). In a research project coordinated by Eurac Research, snow data from more than 2000 measuring stations in Italy, Austria, Slovenia, Germany, Switzerland and France was analyzed (Matiu et al., 2021). The results made it possible to reliably describe snow trends up to 2000 meters above sea level. Regional trends sometimes differ considerably, but long-term changes are similar throughout the Alpine region: below 2000 meters, the snow season has shrunk by an average of 22–34 days over the last 50 years; snow on the ground tends to occur later in winter and disappear earlier as spring approaches (Matiu et al., 2021). Similar declines in snowfall over time have been observed for the Apennine region, with the most consistent decreases at elevations below 1650 meters (Capozzi et al., 2025).

Weather patterns have changed and the frequency and intensity of extreme weather, such as flooding, storms, and droughts, has increased (Beniston & Stoffel, 2014; Bocchiola & Diolaiuti, 2010; Copernicus, 2024; CREA, 2019; Seneviratne et al., 2021). Across Italy, drought, alternating with often extreme rainfall phenomena, is putting a strain on agriculture and livestock farming

during the summer season; during the winter, this cycle affects the ski season and related local economies (Bonardo et al., 2024; FAO, 2016; Olesen et al., 2011; Van Passel et al., 2017). Increases in average temperatures and changes in precipitation are affecting mountain flora and fauna, with downstream effects on mountain residents (Rawlence, 2022). High-altitude species (both botanical and animal) are at risk of extinction, firstly because of the gradual disappearance of the environmental conditions to which they have adapted over time – for example, the disappearance of glaciers and slope erosion – and their inability to find alternative habitats, and secondly because of increased competition with other, more competitive species from lower altitudes (Dall'Ò, 2022; Gottfried et al., 2012; Rawlence, 2022; Almond et al., 2022). Many plants now germinate and flower earlier, while birds, amphibians, butterflies, and other invertebrates likewise anticipate critical reproductive stages – an acceleration that may compromise their long-term viability. Moreover, pollinators, herbivores, soil microorganisms, and parasites face indirect risks when the species on which they depend undergo temporal or spatial mismatches (Losapio et al., 2021). Such range shifts come at an ecological and physiological cost: organisms cannot ascend indefinitely. Ungulate populations in the Mont Blanc massif, for instance, have been forced into ever-narrower high-altitude refugia, and several species are predicted to face local extinction as they run out of mountain to climb (Vitasse et al. 2020). Thus, while upward shifts may buffer some effects of warming, the *Alpine ceiling* ultimately constrains their adaptive potential and portends the loss of those species that cannot persist within diminishing mountain environments.

2.2 The Impact of Climate Changes on Mountain Residents

In interviews, mountain residents referred to the same changes documented by natural science studies. They, too, reported increases in average temperatures, higher intensity storms, downpours of water with associated risks of flash flooding and landslides, longer and more intense droughts, less snow in winter, and shifts in the timing and nature of the seasons. They also outlined the downstream effects of these changes on their lives and livelihoods. They reported that higher average temperatures lead to longer agricultural seasons and allow crops to be grown at higher elevations, such as olives and

grapes. Outdoor work can be more comfortable in the winter, though less comfortable in the summer. The higher temperatures also mean that certain plants do not grow as well, that pastures may dry out earlier in the season, and that certain pests, such as the *Drosophila suzukii* fly that attacks blueberry plants, can survive in the mountains. The higher temperatures can also cause permafrost to melt creating more dangerous high elevation situations for people and animals. Higher intensity storms, flash flooding, and landslides place people and animals at risk and can damage crops, fields, and infrastructure. Longer and more frequent periods of drought in turn challenge crops and dry out pastures, reducing forage available to livestock. Less snow in the winter poses challenges for the winter tourism sector. Less snow in the winter can also mean less water in the summer. Shifts in the timing and nature of the seasons in turn affect when flowers bloom and make it more difficult to understand when crops should be planted and harvested. All of these changes affect the ecosystems on which Alpine animals and plants live and make it such that traditional ecological knowledge, or knowledge of the specific mountain environment and climate and the relationship between people, animals, plants, and weather, is becoming less reliable.

2.3 Social Changes

At the same time as climate changes are affecting mountain weather patterns and ecosystems, social changes have also fundamentally altered mountain areas in Italy. The primary changes mentioned by mountain residents include rural depopulation and the abandonment of agriculture, which accelerated in the decades after World War II as people moved to the industrialized lowlands for jobs. The valley bottoms, once the site of intensive agricultural holdings, have been progressively converted into industrial complexes and residential developments (Dax et al., 2021). As people left the mountains for jobs in factories and industry, they abandoned agricultural activities that have since slowly disappeared, with the number of farms declining by 75% between 1961 and 2010 (Spinelli & Fanfani, 2012). Rural areas have depopulated, and widespread land abandonment has followed (Dax et al., 2021; MacDonald et al., 2000; Plieninger et al., 2016). Those farmers who have remained have faced pressure to expand, industrialize, and integrate into global mar-

kets, though this has not necessarily increased the prosperity of rural areas and has placed farmers in positions of uncertainty and insecurity tied in part to a volatile global agricultural system (Dax et al., 2021; Flury et al., 2012; Nori & Farinella, 2020; Rivera et al., 2018; Whitaker, 2024).

Economic activity has increasingly shifted toward tourism; in many Alpine regions, hospitality and recreational services now account for nearly half of local incomes and employ a significant proportion of the workforce, particularly through winter-sports resorts and nature-based activities (Corrado & Gobbi, 2006; Bätzing, 2015). As small-scale farms have declined, guesthouses, guided-tour businesses, and outdoor-education providers have become the principal engines of rural livelihoods (Corrado & Gobbi, 2006). Ecological changes have followed: abandoned pastures have given way to advancing forests, altering the composition and distribution of mountain flora – key sources of forage for livestock, nectar and pollen for pollinators, and habitat for wild fauna (Bindi, 2022; Malandra et al., 2019; Tasser et al., 2024). Reforestation and deforestation, habitat destruction and fragmentation, pollution, and impactful infrastructure can exacerbate and amplify the consequences of climate change (Losapio et al., 2021).

Other social factors affecting mountain residents include economic stagnation, exacerbated by the 2008 economic crisis (Di Quirico, 2010; Storm, 2019). There has been an overall decline in the quality and quantity of services in mountain areas including healthcare, childcare, and schools, as well as veterinary and agricultural extension services for farmers. Without adequate services, mountain areas become less accessible and livable. It can be difficult for producers in mountain areas to sell products produced at the cost of their production – which is higher in the mountains – especially as production costs have increased, markets have shifted, and low-cost industrial products dominate supermarket shelves (Bentivoglio et al., 2019; Pagliacci et al., 2022). As people with a long history on the land leave the mountains or conclude their careers, memory, history, traditional knowledge, and understanding of the mountain environment go with them. Additional social changes include demographic changes such as an aging population and an increase in immigration from, for example, Eastern Europe, Africa, India, and the Middle-East (Capacci & Rinesi, 2018; Cottarelli, 2018; Nori & Farinella, 2020). Together, these social, climate, and ecological changes are shaping the environments

in which mountain residents live and work and possible futures for mountain areas.

While the broader literature on mountain areas frequently highlights processes of depopulation and abandonment, it is important to note that this is not a uniform trend across the Italian Alps and Apennines. For instance, the Aosta Valley towns of Courmayeur and Morgex – both included in this research – have not experienced population decline. On the contrary, Courmayeur, a well-known and affluent tourist resort, has seen steady population growth over the last decades, doubling its population from around 1300 in the 1950s to over 2600 today. Similarly, Morgex has benefited from its proximity to ski tourism and second-home ownership, leading to a more stable demographic trend. However, despite these differences, in both the Alpine and Apennine contexts, the agricultural and pastoral sectors – particularly small-scale, family-run farms – have faced significant socio-economic pressure.

The case studies presented here do not aim to offer a representative portrait of entire municipalities, but rather to highlight how individuals and families working in agriculture, beekeeping, livestock farming, hunting, turism and other activities closely tied to environmental conditions are experiencing and interpreting ongoing social, ecological, and climatic changes. These sectors are particularly vulnerable to the impacts of climate change and ecological degradation, and the experiences of those working in them reveal how global transformations take shape at local scales. Despite being situated in demographically and economically diverse areas, these actors share a common exposure to environmental uncertainty and a reliance on local ecosystems. In this way, the Alpine and Apennine case studies are connected by a shared focus on the transformations affecting people whose livelihoods are most deeply entangled with the natural world. Social, climate, and ecological changes are shaping the environments in which mountain residents live and work and possible futures for mountain areas.

3. The Research Sites

Study results are based on ethnographic research conducted in Garfagnana, a mountain area of the Tuscany region of the Italian Apennines, and in two locations in the Italian Alps: the Lombardy Alps (focus on the Val Camonica and Valtellina) and the Mont Blanc area in the Valley of Aosta (focus on the towns of Courmayeur [2740 inhabitants] and Morgex [2090 inhabitants]).[1]

Garfagnana is located in northwest Tuscany. It is bordered by the Apennine mountains and the Apuan Alps. The landscape is defined by forests, agricultural fields and pastures, and small towns, as well as some larger towns and industrial activity, particularly at the lower elevations. Interviews and participant observation in Garfagnana, Tuscany were conducted between July 2021 and July 2023. 34 small-scale farmers and 3 beekeepers were interviewed (28 [75.7%] men and 9 [24.3%] women; age range: 22 to 72; average age: 51). These interviews were conducted as part of a project on the impact of climate and environmental change on farmers.

The Val Camonica and the Valtellina are located in the Alps of the northern Italian Lombardy region. The valleys are marked by narrow valley bottoms and towering peaks. The landscape is also defined by a mix of agriculture and industry, housing, and towns at the lower elevations; pastures, fields, and forests at the middle elevations; and pastures, lakes, and rocky peaks at the highest elevations. Research was conducted between December 2017 and December 2018 and between June and August 2019. 44 small-scale farmers and 23 beekeepers were interviewed (26 [38.8%] women, 41 [61.2%] men; age range; 27 to 82; average age: 47). These interviews were conducted as part of a larger project on the impact of climate and environmental change on mountain farming and on farmer well-being.

The Valley of Aosta is an autonomous region in northwestern Italy. It is bordered by Auvergne-Rhône-Alpes, France, to the west; by Valais, Switzerland, to the north; and by Piedmont, Italy, to the south and east. The Italian side of Mont Blanc is an area characterized by a huge variety of biodiversity, habitats, and environments. In the space of 70 years, there has been a shift

1 The work on the Apennines (Garfagnana) and the Val Camonica and Valtellina (Alps) was conducted by Sarah H. Whitaker, the work on the Valle D'Aosta and the Mont Blanc (Alps) by Elisabetta Dall'Ò.

from an economy based on grazing and mountain agriculture to a "cementing" and infrastructuring of the highlands: ski resorts, cable cars, second homes, resorts, and restaurants have largely replaced stables, Alpine pastures, crops, and forests. The research is part of a larger project on perceptions of climate change on-going since 2014. The study is based on 57 in-depth interviews with: 15 professional hunters, 16 ski instructors and mountain guides, 4 mountain hut managers, 10 small-scale farmers, 7 livestock farmers, and 5 restaurant owners. Overall, 67 % of respondents were male and 33 % female with ages ranging from 25 to 68 years, ensuring perspectives across generational and gendered lines in mountain economies. Notably, in the hunters' cohort only one of the fifteen interviewees was female.

Interviews lasted anywhere from one to five or more hours. Interviews may have begun at a table, but transitioned to, for example, the farmland or ski slopes. Participant observation involved assisting with agricultural activities, attending meetings and presentations, and touring farms, restaurants, mountain huts, and ski areas. Textual data was analyzed using a combination of inductive and deductive coding and thematic analysis (Bernard et al., 2016). All interviews were conducted in Italian.

4. Results

With these interlinked climate, social, and ecological changes in mind, in the following sections, we present case studies of how climate changes are affecting residents of mountain areas, how parallel social and ecological changes intersect with the climate changes, and how integrated human and natural systems remain despite the changes. The examples reveal how and through which practices and discourses these changes are perceived by all social actors involved, allowing us to focus on climate change on a micro scale and to reflect on what these changes could mean for the future of mountain areas. We provide three case studies showing how climate and social changes are affecting hunters, the winter tourism sector, and agriculture (beekeeping and livestock and crop farming) and the ecosystems and landscapes on which they depend. In so doing, we also show how the human and the non-human

are connected in relationships of mutual interdependence that shape adaptations and possible futures for mountain areas.

4.1 Hunting at High Elevation

During field research, it became clear that local professional hunters have a close link with the land that makes them able to grasp, on a micro scale, important aspects of the climate crisis; this connection brings the hunter into contact with global scenarios of change. Their close link to the non-human places them in the position of sentinel of change. In one of the first meetings with hunters from the Mont Blanc area, M. B., from the Courmayeur hunting district said: "we are sentinels of the territory, we are on the territory all year round."

Hunters report significant changes in the hunting season (autumn) compared to previous decades: since autumn is warmer and snow-free, the places where ungulates are shot are now located at higher altitudes. In Valdigne, the mountain community to which Courmayeur and Morgex belong, professional hunters have observed a progressive drop in the altitude of chamois in the summer months, up to the upper limit of the forest. They explain that this is a strategy adopted in recent years by the animals to find shelter and relief from the excessively high temperatures found now even at higher altitudes. But the change does not only affect animal species; the whole Alpine ecosystem is migrating to higher altitudes: plants, insects, fungi, mammals, birds, and parasites are changing their habits. One example is the fly responsible for keratoconjunctivitis, an eye infection afflicting chamois. As temperatures and the treeline have risen to higher and higher altitudes, this fly has also increased its range. Today, chamois are suffering from eye infections which cause continuous tearing in the animals. With rising temperatures, the fly is set to spread to higher and higher elevations, even above 2000 meters. In a field interview a hunter explained: "everything in the Mont Blanc area is changing invisibly, as if out of time: the seasons, the glaciers, the forest, the animals … they are no longer the same; even the chamois eyes are different ... they seem to cry".

In addition to increasing the range of the fly responsible for eye infections in the chamois, the rise in average temperatures due to ongoing cli-

mate change has shortened the growing season in the mountain areas where the chamois live. As a result, pasture grasses become depleted of nutritional properties earlier in the season, and thus do not provide suitable fodder for chamois kids at the critical time of weaning. To date, scientific studies confirm hunters' perception and suggest that temporal trends in size are an indirect result of changes in resource availability and quality brought about by climate change, which impair the ability of individuals to acquire resources and grow (Losapio et al., 2021). The higher temperatures also mean that, in order to avoid increasing their core temperature, chamois avoid feeding at warmer times of day, and do not forage enough in general.

Climate change is also affecting the wild medicinal herbs that chamois feed on, such as the génépy (*Artemisia glacialis*). The génépy grows at very high altitudes (1800 to 3200 meters) and in places that are difficult to access, such as moraines, rock cuts, and scree at the foot of glaciers. It is a favorite healing plant of the chamois, as well as of other animals. The génépy is now at risk of extinction due to global warming, and its disappearance will constitute a cultural as well as an ecological and ecosystem loss as the génépy is also used by humans to make a liqueur and for its anti-inflammatory qualities (Fassino, 2021; Pieroni & Giusti, 2009).

This example shows the relationships and connections between and among the human and the non-human in the Alps. Their futures are intertwined through climate changes that affect people, plants, and other animals alike. Hunters are on the frontlines of these changes and adapting their practices accordingly, hunting at different times of day and in new locations. They have begun to keep detailed field journals – recording freeze-thaw dates, flowering times, and ungulate corridor shifts – and to share these data with mountain ecologists in participatory monitoring programs. Some have also adopted GPS-enabled tracking collars on game to map elevation migrations in real time, while others collaborate in small reforestation and Alpine grassland restoration projects to bolster habitat resilience. The deep, affective bond hunters have with place can give rise to solastalgia – a form of existential distress provoked by environmental change (Albrecht, 2006) – as hunters witness the loss of familiar landscapes and species. Despite the adaptive capacity of plants and animals, the intensity and speed of the current climate crisis may exceed their – and their stewards' – ability to adapt. Hunters, as both

observers and participants in these shifting ecologies, thus occupy a unique role as emotional and epistemic sentinels of Alpine change.

4.2 Winter Tourism: Skiers in T-Shirts in the Middle of Winter

Starting in the 20th century, temperatures in the Mont Blanc area began to rise steadily, breaking all previous heat records, and episodes of extreme cold, became very rare, until they almost disappeared. In the last forty years only the winters of 1985 and 1991 show very cold temperature averages, and in the last thirty the climate has begun to warm again as it never had before. The progression seems unstoppable; each decade surpasses the previous one in annual thermal averages, setting the record bar a little higher. The "hottest year," the "hottest summer," the "mildest winter," are all in the first two decades of the 21st century, and 2023 holds the record for the hottest year since weather records were first taken. In January 2023, in Aosta, 22° Celsius were recorded; an anomaly, to be sure, an exceptional event, but that begs the question of what normality will be in the near future and what tools we will use to cope. While in the city people went out, in disbelief, in short sleeves, on the slopes, skiers immortalized the temperature record by posting evidence of the weather anomaly on social media. A Courmayeur ski instructor, B. B., explained how some of her clients, on those hot days, complained about the snow conditions:

> They kept saying the snow sucked, they were not having fun, they had wasted the day, they wanted a refund! They just didn't understand that at these temperatures it was already a miracle that there was snow! And then of course at 13° Celsius it becomes a slush, but they don't understand that if in January you ski without a cap and without gloves it's because there is something sick … but for them anyway the mountain is only to be used for fun; if there is no snow here they go somewhere else, while for us instructors, snow is work.

That same winter, in Dolonne, Courmayeur, one of the managers of the fun park, the slope for children and beginner skiers, said disconsolately that despite all the efforts put in, they would not make it to Easter with the ski season. Too little snow and too high operating costs to keep all the lifts open, and

even artificial snowmaking – which covers 70 percent of the entire area and is a practice that has become customary over the past 30 years – would have been impossible given such high winter temperatures and the lack of water in the reservoirs. "You see, at these altitudes [1300 meters] the snow is all gone long ago … flowers have already sprung up, snowdrops in the meadows; but it wasn't like this before ... there were meters of snow here, and now instead we close, and we reopen at Christmas" (March 26, 2022).

This example shows how the winter tourism sector is being affected by increasing average temperatures, shifts in the timing of the seasons, and declining snowfall. These changes are an inconvenience for tourists, but they are an important change for those who live in the mountains and depend on certain climate and weather conditions for their livelihoods. The consequences are different. While skiers can pursue snow elsewhere, the slope operators must face the reality of the changes, and their economic impact, directly. Moreover, the early closure of even small beginner slopes disrupts year-round employment for park staff and ripples through the local supply chain – from snow-grooming services to hospitality businesses – undermining community resilience. This reliance on a predictable snow season also shapes the social fabric of Mont Blanc area, where winter recreation has long been a cornerstone of communal identity and intergenerational traditions; its loss therefore represents not only an economic shock but a new challenge for community identity and culture.

4.3 Agriculture: Livestock Farming, Crop Farming, and Beekeeping

While agriculture in the Alps and Apennines has significantly declined in recent decades, a contingent of farmers does continue to practice smallholder agriculture in mountain areas of Italy (Dourian, 2021; Lupi et al., 2017; Milone & Ventura, 2019; Sivini & Vitale, 2023). As they do so, they face the myriad social, ecological, and climate changes outlined above and must deal with the consequences of these changes on their farming practices. While each of the changes can affect farming independently, to understand the true impact of the changes on farmers, we need to understand how the changes intersect

(EEA, 2010; MacDonald et al., 2000; NORDREGIO, 2004; Terres et al., 2015). Here, we look first at livestock and crop farming and then at beekeeping.

4.3.1 Livestock farming when the water runs out

Above, we saw how higher average temperatures and lower snowfall are affecting winter tourism. Less snow will also have an increasingly important impact on water reserves, augmenting the risk of drought in the spring and summer seasons, with immediate effects on the agricultural sector. In mountain economies, water is indispensable for pastures and for the supply of fodder, the staple food of, for example, dairy cattle, sheep, and goats. Pastures and vegetation, under conditions of water stress, accelerate maturation to the detriment of quality. They do this because their biological goal, explains Mauro Bassignana, director of the IAR, Institut Agricole Régional of the Aosta Valley, is to preserve the species, and to reproduce as quickly as possible in the event of drought. Less forage means less milk production, hence fewer dairy products, a sector of excellence for the Aosta Valley.

> While it is true that we can supplement the diet of these animals with fodder, already today, with the war in Ukraine, prices have risen a lot. I am thinking of wheat and soy ... while profit margins in this sector are minimal. In addition, if we are talking about Fontina cheese, the specifications do not allow the use of fodder that is not local ... The lack of water, especially for those who are not in areas fed by glaciers – which is another type of criticality – could be a problem in many areas of the region. (Interview 28 March, 2022)

Similarly, a cattle farmer in the Val Camonica explained how drought in the lowland areas of Italy had driven up demand for hay from northern Europe, which caused prices to increase (Schirpke et al., 2019; Whitaker, 2023a). Even as the drought resolved in Italy, prices stayed high because the drought struck northern Europe, increasing demand for Italian hay.

As we saw with the chamois, lower quality and quantity of forage can affect animal growth and health. However, the implications for livestock cannot be reduced to simple biological consequences, as farmers operate within a complex system of economic, legal, and regulatory constraints. Malnutrition is neither tolerated nor legal under current EU and Italian animal welfare leg-

islation. In response to forage shortages, many farmers already purchase supplemental feed, including high-protein fodder, sometimes from outside the region. However, these adaptations increase production costs and may affect the nutritional and organoleptic properties of the milk, potentially challenging the compliance of local products with the Fontina PDO standards (Fontina is a semi-soft, raw cow's milk cheese produced exclusively in the Aosta Valley and protected under the EU Protected Designation of Origin scheme).

To mitigate the effects of heat stress on livestock and avoid decreases in milk yield, some farms – particularly larger, more industrialized operations – have begun to adopt technological solutions such as mechanical ventilation and misting systems in their barns. These technologies, however, come at a high cost and are generally inaccessible to small-scale family farms or to Alpine pastures located at higher elevations. This disparity highlights how the impacts of climate change tend to disproportionately affect those who are already more economically vulnerable or situated in more remote areas, where access to adaptation technologies is limited. In this sense, climate-induced forage scarcity and heat stress interact not only with ecological systems, but also with broader socio-economic and political structures. The viability of high-altitude dairy production will depend as much on institutional support and adaptive capacity as on environmental conditions themselves (Dall'Ò, 2021; Hopping et al., 2016).

In this example, we see how on a local scale, the impact of an event such as the war in Ukraine or drought in a different part of the world, apparently very distant from the Alpine context, intersects with local changes to weather and climate, triggering and amplifying them. The repercussions vary by context, but certainly are more severe for those communities that find themselves living in conditions of previous vulnerability and that have fewer resources at their disposal, such as many rural mountain communities. When examined alongside the impact of less snow on winter tourism, we see how different sectors of the mountain economy become connected through climate change. It is possible that the future of both depends on the ability of the sectors to address this challenge and identify a shared path forward.

4.3.2 Crop and livestock farming as the forest advances

In both the Alps and Apennines, the consequences of species migrations towards higher altitudes driven by climate and ecological changes are being observed by mountain residents. One significant migration is that of the treeline: a natural boundary within which trees manage to survive due to precise climatic and environmental conditions (Rawlence, 2022). Since World War II, the area occupied by forests on the massif of Mont Blanc has increased by 60 percent. The treeline is now at around 2,250 meters, but could reach 3,500 meters by 2050 (Gerardi, 2019). The colonization of vegetation from the bottom up, above the forest line, and the replacement of high-altitude plant species affects the entire Alpine region from Nice to Vienna (Rawlence, 2022). When the climate changes, the treeline changes accordingly; it is among the more visible effects of climate change in the mountains (Frate et al., 2018; Noce et al., 2023). The tree-line of the Mont Blanc area contains non-human figures such as wild and farm animals, and even insects and plants, which have always played a crucial cultural role for Alpine communities; from founding myths, and legends, to mountain economies (e.g., livestock farming, milk and cheese production, beekeeping, hunting). These species are now of great importance not only because they are "perceiving and bringing" the first signs and symptoms of the "climate crisis", but also because they are anticipating it as "sentinels" (Lakoff & Keck, 2013). The abandonment of rural and agricultural areas has also facilitated the spread of forests.

Like in the Alps, in the Apennines, the distribution and nature of forests is also shifting due to social and climate changes (Bonanomi, 2020; Rogora et al., 2018; Vitali et al., 2018). As residents of Garfagnana explained, while trees, particularly chestnut and birch trees, have always grown or been cultivated at the middle and high elevations, or cultivated intentionally on more precipitous slopes less suited to crops, since the 1960s and the rural and agricultural abandonment that has occurred since then, forests have come to dominate at all but the highest elevations. Abandoned pastures and fields have filled in with trees. As a mountain resident explained, trees have "grown up right to people's doorsteps."

In line with this advancement of the forest has come an increase in the number of wild animals. A farmer explains: "At the scale of agriculture in general, all this means that now our territory has been abandoned and has been repopulated by wild animals ... now anything you want to do – even a vegetable garden – you have to put in two meters of fencing" (male, early 50s, livestock and crop farmer). The increase in the number of wild animals is tied to the presence of more suitable habitat (forests) and the decline of people working the countryside. As the forest advanced and there was less competition for space from people working the land, the numbers of wild boar, deer, roe deer, and wolves has increased (Bailly, 2021). As one farmer put it: "We don't know what to do ... these animals, nobody can stop them" (female, early 70s, livestock and crop farmer).

Farmers report widespread damage to their crops and herds. Wild boar destroy agricultural land, plowing through fences or burrowing beneath them, destroying entire fields in a short time. As a young pig farmer explains: "If there is a plant, a deer or a roe deer will eat it. If you have potatoes a wild boar will destroy everything. The first problem is this one, and then if you have livestock you will also think about the wolf." Wolves are perceived as predators who slaughter animals at pasture, sometimes even those fenced in. As a livestock farmer in Garfagnana explains: "we used to have goats but we sold them because of the wolf ... The wolf is beautiful, but for those who have animals, they give you goosebumps." Farmers in the Alps report similar problems: "That is the biggest problem for us.... the wolves are taking over everything, they get everywhere. It is risky for dogs, even pet dogs, not just hunting dogs, but they are smarter because they stay away" (interview with M. B. on 15 January, 2024, Valdigne, Mont Blanc area).

Since wolves are protected by law, farmers can defend their animals only through the use of guard dogs or fences constructed specifically to keep out wolves. This has cascading effects on animal health, farm economy, and tourism. Keeping animals fenced into a limited space all year, even if only for the night when the animals are at greatest risk, means that animals must be fed hay, an added expense for the farmer. In addition, keeping animals on the same plot of land increases their risk of exposure to parasites. Sheep and goat farmers especially reported that, as a result, they have to treat their animals for worms more frequently than they used to.

In turn, tourists and passerby complain about the presence of guard dogs which can be threatening and dangerous if improperly approached. Farmers face pressure to keep their dogs from harassing passerby, but the role of the dog is precisely this, in order to ensure the pasturing animals are safe. Alternatively, shepherds can stay with the animals when they are at pasture, but there are fewer and fewer people willing and/or able to shepherd the animals in the high, and even low, elevations. Hiking the crest of the Apennines in Garfagnana, one can sometimes still find herds of animals, often shepherded by Moroccan, Malian, or other North African shepherds, immigrants to Italy (Nori & Farinella, 2020).

This example shows how parallel climate and social changes are driving shifts in the distribution and nature of mountain flora and fauna. Increasing average temperatures and changes in precipitation combine with rural depopulation, the abandonment of agriculture, demographic changes, and economic changes to alter mountain ecosystems, with cascading effects on farmers, hunters, and other mountain residents. As mountain residents adapt to the changes, they in turn shape the mountain environment.

4.3.3 Mountain beekeeping under conditions of change

Beekeepers and bees depend on mountain ecosystems and weather patterns in ways that make them particularly susceptible to change. As an Alpine beekeeper explained, honeybees are sentinels of change, "bioindicators … a sign of the environment we are living in" (38-year-old, male), as they are highly vulnerable to alterations to the climate and to ecosystems (Cunningham et al. 2022; Taylor, 2019). Evidence from the Alps and across the world suggests that changes to weather patterns, ecosystems, and landscapes are affecting honeybee health and survival (Le Conte & Navajas, 2008; Slathia & Tripathi, 2016; Van Espen et al., 2023), which is having downstream effects on beekeepers and beekeeper productivity. Like hunters, beekeepers, attentive to the health and behavior of their bees, are "thermometers of the health of the environment" (38-year-old male). They are noticing important changes to local climates and ecosystems that are affecting their beekeeping practice.

Weather and the timing of the seasons influence bee survival, honey production, and behavior (Gerlach, 1985; Holmes, 2002; Le Conte and Navajas, 2010;

Spivak, 1992). Beekeeping depends on consistent and predictable flowering times and flowers full of nectar and pollen. It is not surprising then that the climate and ecosystem changes most cited by beekeepers are changes that affect seasonal weather and flower blooms. These include: increasing variability in the weather, temperature changes, other meteorological changes (drought, excessive rain, windstorms), and changes to the timing of the seasons and flowering times.

In particular, beekeepers feel strongly that the spring – the most important season for the production of honey – has changed, arriving early but then reverting to a cold climate. "These springs are crazier every year and make it difficult for the bees" (55-year-old, female). The spring is marked by "intense periods of cold and rain" (41-year-old, male) whereas it once was defined by warm days and cool nights. A beekeeper who has been raising bees for decades said: "It seems like a curse: every year the weather conditions during the flowering of *Robinia pseudoacacia* are adverse. Sometimes worse, other times less bad, but we see this important flowering slip away more with regrets than with satisfaction" (60-year-old, male). Cold springs trap bees in the hive and cause them to consume their food reserves rather than produce honey, also leaving them weaker when the good weather eventually returns.

Shifts in the seasons and in average temperatures also affect flowering times and quality. Increasingly frequent, intense, and unpredictable precipitation, droughts, and wind events damage blooms and can reduce nectar production (see also Scaven & Rafferty, 2013): "A normal rainfall does not damage flowers" (59-year-old, male). The timing of blooms has also shifted. Experienced beekeepers report that the timing of the blooms used to be predictable and consistent year to year, "Now, there are no more patterns. All you can do is pay more attention" (62-year-old, male). Such changes in the timing of blooms have been documented across the Alps (Busetto et al., 2010; Colombo et al., 2011), and flowers are projected to continue to bloom earlier under future climate warming scenarios (Olesen et al., 2012).

Blooms that are closer together and shorter also give bees less time to put away honey for the winter season. Spring blooms lost to cold and rainy weather only compound the problem. Beekeepers can find themselves in a difficult position as they try to balance honey production for sale with ensuring their bees have enough honey stores to survive the winter season. Many

of the beekeepers agree that: "The changes have been negative with consequences … there is reduced production of honey and an increase in mortality in the hives" (32-year-old, female). Enrico, the 80-year-old beekeeper introduced above, summarizes the impact of these changes on his beekeeping: "Beekeeping has become a lot harder than it used to be."

Importantly, beekeepers were clear that other social and environmental factors, changes, and challenges are also affecting beekeeping in important ways. The mountain climate, traditionally marked by harsh winters and mild, short summers; the precipitous terrain; diseases and pests, including ones that have recently arrived in the mountains due to globalization and climate change; lack of research on beekeeping; lack of support services, such as agricultural extension services and research on beekeeping; and complex bureaucratic requirements also pose challenges for beekeeping (Whitaker, 2023b; 2024). The abandonment of agriculture has led to the advancement of forests into what were formerly pastures and fields that used to be sources of pollen and nectar for bees. The development of the valley bottom means that there are warehouses and buildings where there was once farmland. Industrialization in the valley bottoms has increased pollution. The spraying of pesticides on fruit trees is a risk to bees. The addition of climate change exacerbates these existing challenges, rendering beekeepers and bees more vulnerable.

Beekeepers may be able to increase the strength and survival of their hives and the hives' ability to handle changes to the weather and environment by selecting for bees with particular traits. Some beekeepers choose to use a specific variety of bee because it is adapted to the mountain environment. Others select for queens possessing certain favorable characteristics, such as a calm temperament, high productivity, and resistance to harsh weather. Luisella, for example, tries to keep queen bees born and raised in the valley. After two difficult years when she lost all her hives to illness and harsh winters, she chose to raise her own queen bees and has had several successful years since. She feels that her own queens do better compared to those imported from outside of the valley that are not as well adapted to the mountain environment. Beekeepers may play an important role in selecting for bees that are adapted to the mountain environment and climate even as that environment and climate changes. In so doing, they may be able to shape

the ability of their bees to deal with the changes (see Le Conte and Navajas, 2008). Beekeepers are also adapting by paying closer attention to the timing of the seasons and the flower blooms, moving their bees to high elevation pastures to take advantage of specific blooms, checking on their hives more often, and providing supplemental food to their bees if bad weather prevents bees from leaving the hive.

In this example, we see how social changes such as agricultural and rural abandonment; ecological changes, including the disappearance of pastures and fields, the increased presence of warehouses, industry, and houses in the valley bottoms, and shifts in flora and fauna species; and climate changes, including changes to the seasons, to flowering times, and to weather patterns – independently and in the ways they intersect – are affecting bees and beekeeping. Beekeeper observations of change indicate an understanding that the environment and weather have changed, and that these changes are driven by diverse forces. The way they are responding to the changes suggests an understanding that they must adapt their practices, pay increasing attention to the environment and weather, and improvise in response to what they are observing.

5. Conclusion

Mountain residents, animals, and plants are on the frontlines of change, sentinels of what is to come. Mountain residents have noticed that the environment and climate are changing and have identified the ways they are changing, for the human and the non-human alike. The social, ecological, and climate changes observed map onto changes documented in natural science studies of change in mountain areas (see Bonardo, 2024; Dax et al., 2021; MacDonald et al., 2000; Plieninger et al., 2016; Seneviratne et al., 2021). As the case studies show, though, the way the changes affect the daily lives of people living in these areas is shaped by the specific characteristics of the places that are changing and the people, animals, and plants who live in them. To understand the impact of climate change requires understanding these local impacts and putting them into conversation with larger, global level impacts and changes.

The case studies also show how climate change and social and ecological changes are affecting those most exposed to the consequences of the global climate and environmental crisis in the Alps and Apennines: smallholder farmers, ranchers, hunters, and those involved in other activities that depend on the climate such as tourism and winter skiing. While these groups of individuals may seem to be separate in their use and understanding of the mountain environment, the examples show how the climate crisis links them all, both to each other and to the larger global context of change in which they are enmeshed. Their individual observations of change, brought together, could lead to a greater understanding of the current environment and climate that might point to paths forward for all. While there may be areas of conflict, for example in water management for a longer ski season versus a productive agricultural season, the future will require collaboration and cooperation among those dependent on a changing climate and environment for their livelihoods.

The examples also show the deep interconnections linking humans with the non-human in mountain areas and the profound mutual dependence that exists between them. The impacts of the climate crisis are inscribed in the bodies and behavior of animals, as they are in the ecosystems they, and we, inhabit. The sense of loss that many local inhabitants express in response to these visible transformations – warmer winters, retreating snowlines, animals behaving in unfamiliar ways – can be interpreted through the lens of *solastalgia*, the emotional or existential distress caused by environmental change to one's home. This place-based form of ecological grief reinforces the idea that environmental change is not only physical, but also deeply psychological and cultural.

Solutions to the climate crisis will be rooted in understanding of the ways in which climate, social, and ecological changes are interconnected at and across local and global scales. They will also require us to understand our interdependence on the non-human actors with whom we share our environments. From the water cycle to the implications of drought for grazing and winter skiing, from phenological maturation to the success of beekeeping and the survival of bees, from species migration to hunting, from temperature increases to animal diseases, and from shifts in tree distribution to the destruction of fields and the death of livestock, climate change plays out

in unique ways at local scales as it intersects with recent and on-going social and ecological changes. In the face of these challenges, mountain residents are not only observers but also agents of adaptation. Farmers experiment with crop calendars and irrigation strategies; hunters change their practices to respond to animal behavior; tourism workers adjust to shorter seasons and rising operating costs. These adaptations, while often reactive and limited by resources or geography, signal both resilience and a pressing need for support. Future pathways should strengthen this local adaptive capacity through policies that are ecologically grounded, socially just, and attentive to the specific needs and knowledge of mountain communities. Building these alliances – between humans and non-humans, between science and local knowledge, and across generations – may be one of the most effective strategies for navigating the uncertain futures of the Anthropocene.

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